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ORIGINAL ARTICLES.

I.—Notes on some Upper Cretaceous Fish-remains from the Provinces of Sergipe and Pernambuco, Brazil.

By Arthur Smith Woodward, LL.D., F.R.S., of the British Museum.

(PLATE VII.)

I AM indebted to Professor Orville A. Derby for the opportunity of studying some fish-remains from the Cretaceous of North-East Brazil, which were examined by the late Professor Cope and partially described by him, without illustrations, in 1886. I had the privilege of seeing some of these fossils at Philadelphia in 1890, and made a few notes which were incorporated in the British Museum Catalogue of Fossil Fishes. I have now undertaken a renewed and more detailed study of the collection, which suggests the desirability of publishing the following supplementary observations.

Enchodus subæquilateralis, Cope. (Pl. VII, Figs. 1, 2.)

1886. *Enchodus subæquilateralis*, E. D. Cope: Proc. Amer. Phil. Soc., vol. xxiii, p. 3.

This species is represented only by palatine bones ('premaxillaries' of Cope) and by a tooth probably of the dentary bone, from Maria Farinha, Province of Pernambuco. The type-specimen (Pl. VII, Fig. 1) exhibits the palatine tooth, already described by Cope. A second specimen (Fig. 2), exposed from the inner aspect, shows that the palatine bone is short and stout, with the ethmoid articulation extending to its anterior end, where the tooth is fixed and directed downwards.

Paleobalistum flabellatum, Cope, sp. (Pl. VII, Fig. 3.)

1886. *Pycnodus flabellatus*, E. D. Cope: Proc. Amer. Phil. Soc., vol. xxiii, p. 6.

1895. *Paleobalistum flabellatum*, A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. iii, p. 275.

The only known example of this interesting Pycnodont is exposed from the right side and shown of one-half natural size in Pl. VII, Fig. 3. It lacks the greater part of the head, besides the front half of the dorsal and ventral borders, but is sufficiently well-preserved to leave no doubt as to its generic determination. Immediately behind the rather large orbit (*orb.*) a cluster of slender ossified gill-supports is seen, and below this is part of the widely expanded left preopercular (*pop.*) exposed from its inner face. In the axial skeleton of the

trunk there are traces of the expanded bases of the neural and hæmal arches, which must have nearly encircled the persistent notochord; and just above these expansions in the neural arches of the abdominal region the interdigitating plates, which form a rigid connection between the bases of the neural spines, are conspicuous. The ribs are winged as described by Cope, but the appearance of a "continuous wall" noted by him is partly due to an inner view of the underlying scales of the left side of the fish. Impressions show that the hæmal spines within the caudal fin are fan-shaped. The slender left clavicle still retains traces of its inferior expansion (*cl.*), which is mistaken by Cope for a coracoid bone; while the series of basal bones of the pectoral fin is obviously incomplete, and so does not place the Pycnodontidæ in the Isospondyli, as supposed by Cope. All the fins are very imperfect, and it is impossible to determine how many rays were originally present in the dorsal and anal fins, which are incomplete in front. There is thus no reason for Cope's conclusion that the anal fin is unusually short. The caudal fin, which is shown chiefly as an impression, displays the peculiar shape characteristic of *Palæobalistum*. Remains of the squamation occur over the whole of the abdominal region and, though more delicate, over the middle part of the flank of the caudal region; but the scales are represented chiefly by their thickened ribs ('rhabdopleurs' of Cope), by which the transverse rows are clearly spliced together in the usual manner. Cope did not observe this splicing, but described the 'rhabdopleurs' as "not segmented." As noted by him, the number of transverse rows of scales is equal to that of the vertebral segments. No traces of scale-ornament are observable.

The condition of the vertebral column and the shape of the caudal pedicle and caudal fin prove that the Pycnodont now described belongs to the genus *Palæobalistum*, which occurs both in the Upper Cretaceous and in the Eocene of the Old World. It differs from *P. Pawarti* (Upper Cretaceous, Marne, France), in having the scales continued over the middle of the flank of the caudal region; but agrees in the latter respect both with the type-species, *P. arkiculatum*[1] (Upper Eocene, Monte Bolca), and with *P. Gaudeli* (Cretaceous, Hakel, Mount Lebanon). In the strength of this caudal squamation the Brazilian fish is intermediate between the two last-mentioned species, but in the shape of its caudal fin resembles most closely *P. Gaudeli*.

Palæobalistum flabellatum was discovered in "the southern centre of the Province of Sergipe del Rey."

Apocæpodon sericeus, Cope. (Pl. VII, Figs. 4, 4*a*, 4*b*, 5, 5*a*.)

1886. *Apocæpodon serieus*, E. D. Cope; Proc. Amer. Phil. Soc., vol. xxiii, p. 2.

I have already remarked[2] that the dentition named *Apocæpodon* is intermediate between that of the typical Myliobatidæ and that of the

[1] In the British Museum Catalogue of Fossil Fishes, pt. iii (1895), scales are said to be confined to the anterior half of the trunk in *P. applanatum*; but an example of this species acquired by the British Museum since 1895 shows numerous very delicate ribs of scales in the caudal region. (B.M. No. P. 9850, described and figured by Heckel; Denkschr. k.k. Akad. Wiss. Wien, math.-naturw. Cl., vol. xi, p. 229, pl. v.)

[2] Proc. Geol. Assoc., vol. x (1888), p. 207.

Cretaceous *Ptychodus*. The teeth are well described by Cope, but the illustrations of them now given are needed for the satisfactory understanding of their characters. The lateral ends of the median teeth (Fig. 4) are as irregular in their bevelling and truncation as those of *Ptychodus*; and the shape of the side-teeth (Fig. 5) must doubtless have been equally irregular. The appearance of the vasodentine is remarkably similar to that of *Ptychodus*; and the enamelled surface of the flattened crown bears wrinkling (Fig. 4*b*) suggestive of that round the borders of the teeth of *Ptychodus*, but all the wrinkles are directed antero-posteriorly, and there is no transversely ridged central area. As described by Cope, the root is sharply constricted from the crown (Figs. 4*a*, 5*a*), and it differs from that of the teeth of *Ptychodus* in being very slightly marked on its lower face (Fig 5) with a few broad antero-posterior grooves. There is evidence of at least three paired lateral series of teeth, which rapidly diminish in size outwards.

Apocopodon sericeus occurs in the Cretaceous of Maria Farinha, Province of Pernambuco.

Rhinoptera prisca, sp. nov. (Pl. VII, Figs. 6, 6*a*, 7, 7*a*.)

Vertebræ from the Chalk of Aix and Maastricht are supposed by Hasse to be referable to *Rhinoptera*, but no teeth of this large skate have hitherto been recorded from Cretaceous formations. Two fragments of dentition, apparently of *Rhinoptera*, from the yellow limestone of Maria Farinha, are therefore of much interest.

The most important of these two specimens is shown from the oral aspect, of the natural size, in Fig. 6, and comprises two median teeth, with remains of four paired lateral series. All the teeth are bevelled at the ends in the usual manner, and their coronal surface is flattened or very slightly convex. The superficial layer of the crown has been accidentally removed from all the teeth except one in the outermost row, where it is shown to have been roughened by a fine network of wrinkles (Fig. 6*a*). The root of each tooth is traversed by the usual antero-posterior grooves, but, as well shown in a second example of a median tooth (Figs. 7, 7*a*), these grooves are comparatively few with relatively large intervening ridges. The median teeth preserved are nearly three times as broad as long; the teeth of the first paired series are about twice as broad as long; those of the second paired series are irregular rhombs as broad as long; while the teeth of the two outer paired series are comparatively small, narrow, and antero-posteriorly elongated. The antero-posterior measurement of each tooth preserved is from 7 to 8 mm., and the width of each tooth is as follows:—median, 22 mm.; 1st lateral, 15 mm.; 2nd lateral, 8 mm.; 3rd lateral, 6 mm.; 4th lateral, 5 mm.

R. prisca is readily distinguished from the oldest species of *Rhinoptera* hitherto described, namely, *R. lucasi*, from the London Clay of Sheppey,[1] by the flatness of the coronal surface of all the teeth, and by the relative proportions of the lateral teeth. It agrees with this species, however, and differs from all others, in the peculiar reticulating wrinkles on the coronal surface of the teeth. These

[1] A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. i, 1889, p. 126, pl. iii, fig. 6.

wrinkles are not mentioned in the original description of *R. Darwini*, but are well seen on some of the teeth of the type-specimen in the British Museum.

LAMNA SERRA, A. S. Woodward. (Pl. VII, Figs. 8, 8*a*, 8*b*, 9, 9*a*, 10, 10*a*.)

1889. *Lamna serra*, A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. i. p. 409.
1894. *Lamna serra*, A. S. Woodward: Proc. Geol. Assoc., vol. xiii. p. 198, pl. xi. figs. 11, 12.
1898. *Lamna serra*, E. Priem: Bull. Soc. géol. France [3], vol. xxvi. p. 599, pl. x. figs. 1–5.

Several teeth from Maria Farinha are identifiable with *Lamna serra*, which has hitherto been found only in the Upper Cretaceous (Lower Montian) of Mont Aimé, Marne, France. The dental crown is much compressed, with both faces quite smooth, and the lateral denticles are usually in two pairs. The root is short, not bulging much inwards, while its nutritive foramen is situated in a groove. A typical lateral tooth is shown in Figs. 8, 8*a*, 8*b*, bearing not only two pairs of lateral denticles, but also an additional minute denticle posteriorly. A hinder tooth (Figs. 9, 9*a*) also has three denticles posteriorly, but only one broad denticle in front. A comparatively large anterior tooth (Figs. 10, 10*a*) has the outer lateral denticle reduced to a minute point. All these variations are observable in the British Museum collection of teeth of *Lamna serra* from Mont Aimé itself.

LAMNA APPENDICULATA, Agassiz. (Pl. VII, Figs. 11, 11*a*, 12, 12*a*.)

Three teeth from Maria Farinha agree well with those of *Lamna appendiculata*, but those from the front of the jaw (Figs. 11, 11*a*) exhibit unusually small lateral denticles.

SCAPANORHYNCHUS SUBULATUS, Agassiz, sp.

Several small teeth from Maria Farinha belong either to this or a closely allied species. Similar teeth are found with *Lamna serra* in the Chalk of Mont Aimé.

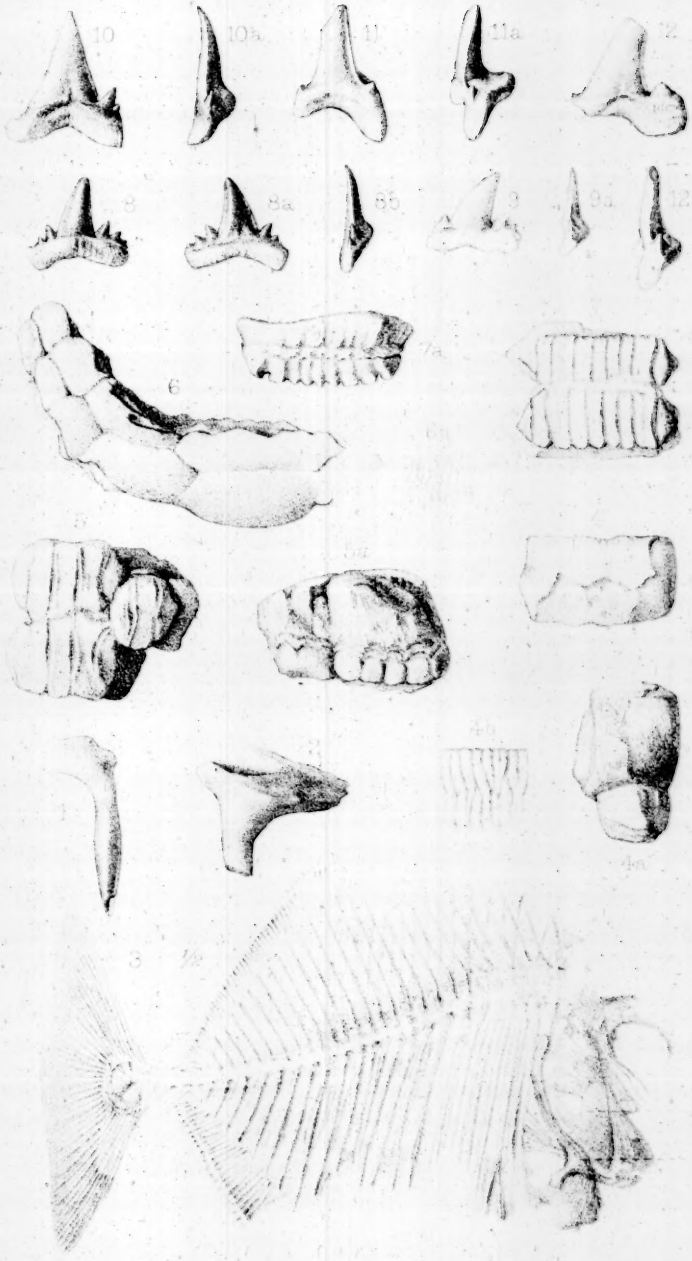
CORAX PRISTODONTUS, Agassiz.

Large typical teeth from Maria Farinha represent this species, as already noted by Cope.

The fish-fauna now described evidently represents the latest part of the Cretaceous period, and is of special interest as affording the earliest known evidence of Myliobatid skates. The occurrence of *Lamna serra*, which is found with *Palæobalistum* in Northern France, is also remarkable.

EXPLANATION OF PLATE VII.

FIG. 1.—*Enchodus subæquilateralis*, Cope. Right palatine, outer aspect.
" 2. Ditto. Right palatine, inner aspect, showing ethmoid articulation.
" 3.—*Palæobalistum fabellatum*, Cope, sp. Imperfect fish, one-half nat. size. *cl.* clavicle; *orb.* orbit; *pop.* preopercle; *um.* humerus.
" 4.—*Ancistrodon segnicus*, Cope. Median tooth, coronal and (4*a*) lateral aspects, with part of superficial ganodentine much enlarged (4*b*).
" 5.—Ditto. First and second lateral teeth, interior and (5*a*) anterior aspects.
" 6.—*Rhinoptera prisca*, sp. nov. Portion of dentition, with part of superficial ganodentine much enlarged (6*a*).
" 7.—Ditto. Two median teeth, interior and (7*a*) anterior aspects.



A.S. Woodward del. et lith. West, Newman imp.

Upper Cretaceous Fish-remains from Brazil.

Fig. 8.—*Lunula silva*, A. S. Woolw. Lateral tooth, inner, (8*a*) outer, and (8*b*) lateral aspects.

" 9.—Ditto. Lateral tooth, inner and (9*a*) lateral aspects.

" 10.—Ditto. Anterior tooth, outer and (10*a*) lateral aspects.

" 11.—*Leaena appendiculata*, Agass. Anterior tooth, outer and (11*a*) lateral aspects.

" 12.—Ditto. Outer and (12*a*) lateral aspects.

Except Figs. 3, 4, 6*a*, all the drawings are of the natural size. The original of Fig. 3 was obtained from the Province of Sergipe del Rey; all the other specimens from Maria Farinha, Province of Pernambuco. All specimens in the National Museum, Rio de Janeiro.

II.—The Charleston Earthquake of August 31st, 1886, in a New Light.

By William Herbert Hobbs,

Professor of Geology in the University of Michigan, and Secretary to the Committee on Seismology of the American Association for the Advancement of Science.

(WITH A MAP.)

WITH few exceptions, surface dislocations within the earth's crust or 'earthquake-faults,' have been described in connection with all earthquakes of large proportions.[1] The Charleston earthquake of August 31st, 1886, stands out in some contrast with most others in this particular, and it is further in contrast with some other earthquakes for the reason that the phenomena recorded in connection with it have not as yet been brought into any relation with the structural geology of the district. A partial explanation of this may perhaps be found in the fact that the area most disturbed—the so-called 'epicentral tract'—is entirely included within the coastal plain of the South-Eastern United States. Upon this plain the basement of rock is covered to very considerable depths by unconsolidated material, and it would perhaps be too much to expect that displacements upon fracture planes in the rock would be revealed in full measure at the surface.

There is good reason to suppose that, in consequence of the easily adjustable nature of the coast deposits, considerable displacements upon fracture planes in the rock basement would at the surface of the ground be represented only by 'ploughshare' effects, opened fissures, and lines of 'craterlets,' the latter due to the rapid expulsion of water at points along the fissures. As shown by the extensive report of Major Dutton,[2] all these phenomena appear to have been developed, thousands of fissures of variable but generally small dimensions having been opened throughout an area for about 600 square miles, while the craterlets were perhaps as large and as numerous as in the case of any other earthquake that has been described. It was further observed that the surface of the ground was in places thrown into a series of ridges and valleys, and that where these furrows cross the railway right-of-way the embankments exhibited changes of the same nature.

[1] For a list of such dislocations formed in connection with the better known earthquakes, see Gerland's "Beitraege zur Geophysik," vol. viii (1907), pp. 250–253.

[2] C. E. Dutton, "The Charleston Earthquake of August 31st, 1886": 9th Ann. Rep. U.S. Geol. Surv., 1890, pp. 203–528.

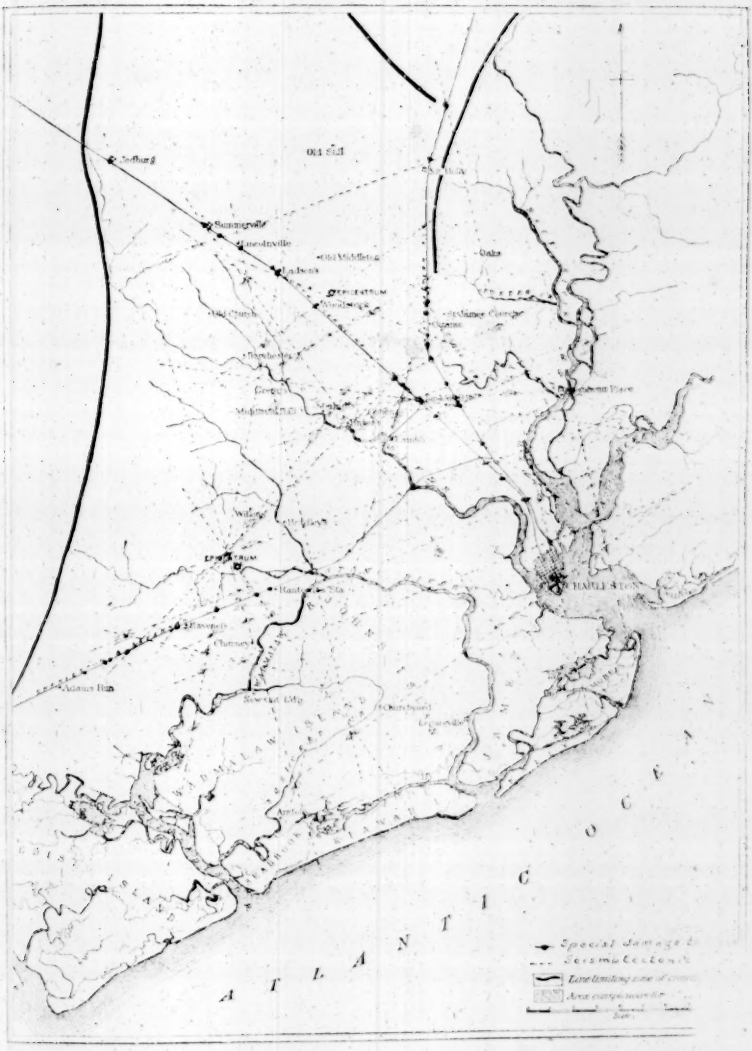
As we have elsewhere pointed out,[1] active craterlets formed in connection with earthquakes, like the fissure springs of which they are the ephemeral and much overgrown representatives, appear to be arranged upon fracture planes, and are located, in many cases at least, at the intersections of such planes. If, therefore, we can secure a correct map of the craterlets within an earthquake district, this map should reveal the outlines, at least, of the fracture system within the province. Notwithstanding the fact that an alignment of craterlets along earthquake-faults and fissures has been often pointed out, it has not generally been thought important to accurately locate them. The unique exception is, perhaps, the map prepared by Major Dutton and printed in connection with his report upon the Charleston earthquake.[2]

A mere glance at the map in question (reproduced with some additional lines on p. 199) discloses the fact that the areas conspicuous for craterlets are aligned within zones strongly marked out in at least a number of instances. Perhaps the most striking examples are to be observed within the area to the south and southwest of the station of Woodstock, where the lines trend north-easterly. Throughout the district affected, however, similar if less striking alignments are to be observed. Such lines mark out lanes of maximum disturbance at the surface, and through them we are enabled to study the distribution of surface intensity of shocks in connection with the Charleston earthquake.

We are in this instance, further, especially fortunate in having another excellent guide to the surface distribution of seismic intensity, and one the full significance of which seems to have been overlooked. The 'epicentral tract' is crossed by three radiating lines of railway which afford well-distributed sections along which location is especially accurate. Grading the intensity of the shocks is furthermore facilitated along the line of the railways for the reason that a structure of essentially uniform elasticity and rigidity extends throughout the sections. The examination of the tracks to collect the evidence upon the distribution of damage was made by Mr. Earle Sloan, apparently a very careful observer. The report shows that sometimes for miles within the 'epicentral tract' the tracks reveal little, if any, serious damage, but such areas of little disturbance are succeeded by relatively narrow zones within which fish-plates are torn out, joints opened, and in a very considerable number of instances the tracks are thrown into a local 'kink' or S-shaped distortion. No simple law was found to determine the intervals between successive points of such maximum derangement to the track, but Major Dutton has drawn the conclusion that upon each railway line the distribution of damage indicates a central maximum from which the intensity falls away upon either side by a law expressed in a very simple reversed curve whose form resembles the Hogarthian line of beauty, and has been named by him an indicator.

[1] W. H. Hobbs, "Topographic Features formed at the time of Earthquakes, and on the Origin of the Mounds in the Gulf Plain": Amer. Journ. Sci., 4th ser., vol. xviii (1907), pp. 245–256.

[2] Loc. cit., pl. xxviii.



Map of area of the Charleston Earthquake of August 31st, 1886.

To the present writer the data given failed to support the view of a gradation in intensity away from any central maximum; but indicate rather many strictly local maxima where the track has been severely wrenched, separated from each other by relatively large distances of damaged minima. In the following lists we have summarized from the report[1] the data collected from the damage observed by Mr. Sloan along each of the three railroads which cross the district.

South Carolina Railway.

Miles.[2]

3⅝. Rails bent and large displacements. Joints opened.
5. Fish-plates torn and joints opened.
6. Joints opened and bed depressed 6 inches.
9. Serious flexure of the track. Train derailed.
10. Ten Mile Hill station. Most marked development of craterlets. Severe distortion of track where branch road to Lamb's leaves main track.
10¾. Another severe flexure of track. Track driven longitudinally to the south-eastward so as to form double or S-shaped curve.
11. Track parted longitudinally with gaps of 7 inches between rail ends. Depression of 18 inches for length of 60 feet.
11½. Opening of joints by as much as 7 inches. (From 14½ to 15½ miles no sharp kinks.) A little beyond Ladson's. Tracks sharply flexed with double curvature.
18½. Another severe flexure.
19¾. Still more complex flexure, and 500 feet further a kink in the track.
20. Many serious flexures.
21. Track distorted vertically and horizontally.
21⅝. Summerville, numerous sharp flexures. (For next six miles little disturbance.)
27½. Jedburgh, severe buckling of track.

North-Eastern Railway.

1½. Lateral flexure of rather large radius. Large track of soft ground moved bodily.
4. Track makes slight curve. Noteworthy distortion.
6. 400 feet of track depressed with a maximum of 22 inches.
7. Track depressed over culvert, etc.
8. Slight flexure.
8 15/16. Embankment 16 feet high depressed 10 inches with indication of forcible vertical wrench.
9. (Approximately.) Whole superstructure shifted 4 inches to the eastward.
9½. Craterlets which ejected sand 13 feet high.
9½. Fish-plates broken and rails parted 8½ inches.
9½. Superstructure shifted to eastward.

[1] Loc. cit., pp. 282–306.
[2] All distances are from the Charleston terminus.

Miles.

10. Most important displacement. Embankment 15 feet high was pushed 4½ feet eastward and kink produced in track.
10¼. Wing wall of culvert broken. Embankment depressed.
11½. Much vertical movement. Trestle damaged.
12. Another great disturbance. Fish-plates broken and joints opened. Cracks running N. 10° E. crossed track, "developing into a series or network of cracks throughout a belt 150 feet wide and 700 feet long."
12⅝. Culvert collapsed.
13½. Brick club house destroyed.
15½. Goose Creek. South end of trestle deflected eastward, and north end to westward.

Charleston and Savannah Railway.

The tracks of this road are those used by the North-Western for some miles out from the Charleston station. From the point of departure no serious damage to the track was found to the east of the Ashley River.

Miles.

11⅜. Ashley River. River banks had been brought nearer together. Drawbridge jammed. West of river the joints of rails were opened.
16⅜. Rantowle's Bridge. Drawbridge shifted. Banks brought nearer together.
18. Rantowle's Station. Track sharply kinked into double fracture. Embankment depressed two feet.
18⅛. Embankment showed a depression of one foot.
20⅞. A maximum of lateral displacement.
22⅞. Here serious flexures which stopped abruptly.
25⅛. Roadbed depressed six inches.
25⅞. 300 feet of track depressed 1½ feet.
26. Sinuous flexures in track.

Upon the map printed with Dutton's report to show the arrangement of craterlets within the 'epicentral track,' we have carefully plotted the data contained in the above lists (see Map, p. 199). Before these data had been plotted, however, lines had been drawn to join the areas of craterlets, and these lines extended. As soon now as the loci of special damage to the tracks had been plotted, it was seen that these points lie where the narrow zones of craterlets extended and intersect the railway tracks. In consideration of the exactness with which these correspondences occurred, there seems to be no reason to doubt (1) that the lines of craterlets extended are the projections upon the surface of the ground of the fracture planes within the rocky basement upon which differential movement occurred at the time of the earthquake; (2) that the areas of craterlets shown upon the map correspond in the main to projections of the intersections of such earthquake-faults; and (3) that the faults are arranged in essentially parallel series, of which two series are more conspicuous than the others. Their prevailing directions are about N. 65° E. and N. 10° W.

The data compiled in the report are susceptible of more elaborate analysis than has here been attempted, since we have sought only the

points of local wrenching of the tracks. As in the case of most earthquakes, the observations show abundant evidence that large blocks of the crust have been shifted laterally and vertically, with lesser adjustments of their component parts. When within the area covered by railway tracks, these adjustments may be measured by those displacements of the right-of-way which are indicated by lateral displacements between points of special wrenching. The Charleston earthquake, in the light of the established relationships, is brought into harmony with the greater number of large earthquakes which have been carefully studied in recent times.

III.—Notes on the Osteology of *Ophthalmosaurus icenicus*, Seeley, an Ichthyosaurian Reptile from the Oxford Clay of Peterborough.

By C. W. Andrews, D.Sc., F.R.S., British Museum (Natural History).

DURING the last few months the preparation of a descriptive catalogue of the magnificent collection of reptilian remains obtained by Mr. A. N. Leeds in the Oxford Clay of Peterborough, has rendered it necessary to examine in some detail the fine series of more or less complete skeletons of *Ophthalmosaurus* preserved in the British Museum. In the course of this examination a certain number of new facts have come to light, and since it will be some time before the detailed description can appear it seems desirable to give a brief account of some of the more interesting points.

Comparison of a number of these skeletons with one another shows that an extraordinary degree of variability in the form of many of the bones occurred, the differences in the shape of certain elements, such as the quadrates or the basi-occipitals, being so great in different skeletons that if these bones were found isolated they would almost certainly be referred to different species. Further examination shows that this would not be justifiable, since two skeletons of which the quadrates differ may have precisely similar basi-occipitals, or *vice versa*, the same thing holding good in the case of other parts. In fact, if any one part of the skeleton were taken as the standard of comparison, five or six species might be established which would not coincide with those that would be formed if another part were employed in diagnosis. These variations are partly real and partly apparent. The real differences seem to be the result of the persistence of a large amount of cartilage in the skeleton of these marine reptiles, the consequence of this being that the actual form of the bones depends largely on the extent to which ossification had proceeded, and in any case is less definite than in land animals. The apparent differences are due to the pressure to which the bones have been subjected. This often leads to deformation without any actual fracture being visible, and is particularly noticeable in the case of the vertebræ, the centra of which may be shortened by nearly half their length without any other distortion. For the above-mentioned reasons it has therefore seemed best to refer all the specimens to the species

Ophthalmosaurus icenicus described in 1874 by Professor Seeley[1] from a shoulder-girdle and fore-paddle included in the Leeds Collection.

Recently a number of papers have been published by Knight,[2] Gilmore,[3] and others on the skeleton of the American Ichthyosaur *Baptanodon*, a contemporary of the English *Ophthalmosaurus*, from which indeed there seems no real reason for separating it, although the above-mentioned writers are not of this opinion.

The restored figure (Fig. 1) of the skull shows that one of the most notable characters is the immense relative size of the orbits, which occupy practically all the lateral aspect of the posterior region, the bones behind and below them (postorbitals, jugal, quadratojugals)

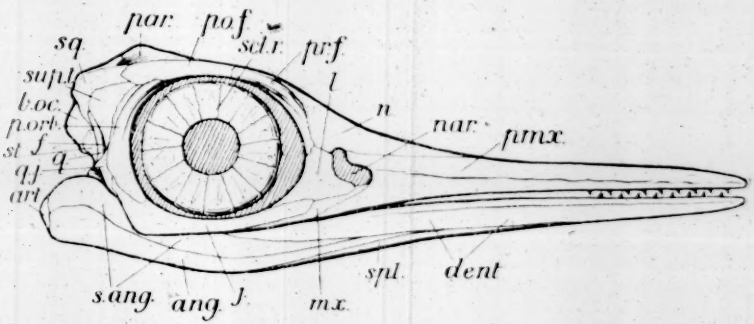


FIG. 1.—*Ophthalmosaurus icenicus*, Seeley. Restored skull from right side. About $\frac{1}{4}$ nat. size.

ang. angular; *art.* articular; *b.oc.* basi-occipital; *dent.* dentary; *f.* foramen between quadrate and quadratojugal; *j.* jugal; *l.* lachrymal; *mx.* maxilla; *n.* nasal; *nar.* external nares; *par.* parietal; *pmx.* premaxilla; *pr.f.* post-frontal; *p.orb.* postorbital; *pr.f.* prefrontal; *q.* quadrate; *q.j.* quadratojugal; *s.ang.* surangular; *scl.r.* sclerotic ring; *spl.* splenial; *sq.* squamosal; *st.* stapes; *sq.f.* supratemporal.

forming only a narrow band. Another peculiar feature is the presence, on the anterior part of the jaws only, of small, loosely attached teeth, which in many specimens are not found, though whether teeth were actually altogether wanting in adult animals or whether they have been lost after death is uncertain.

In some of the specimens the condition of the bones forming the posterior surface of the skull has made it possible to attempt a restoration of this region, of which a number of more or less inaccurate figures, mostly from skulls of *Ichthyosaurus*, have been published. Fig. 2 shows the relation of most of the bones of this region to one another; the pro-otic has been omitted because its position is doubtful, and the parietal also is not drawn. It will be noticed that the whole arrangement seems to be designed to impart the maximum possible degree of rigidity to the quadrates. The stapes (*st.*), which, as usual in the group, have lost their auditory function, unite firmly with the basi-occipital by their expanded inner ends, while their outer extremities fit into pit-like

[1] Quart. Journ. Geol. Soc., vol. xxx (1874), p. 696, pls. xlv, xlvi.
[2] Amer. Journ. Sci. (4), vol. xvi (1903), p. 76.
[3] Memoirs Carnegie Museum, vol. ii (1905), pp. 77, 325.

facets of the quadrates; below they lie in a groove on the upper surface of the pterygoids (*pt.*), the postero-external wings of which also unite firmly with the inner surface of the quadrates. These bones are further supported above by the squamosals (*q.h.sq.*), which closely embrace their upper ends and send down their inner faces processes which overlap the ascending processes of the pterygoids. The squamosals themselves are further supported by the outer ends of

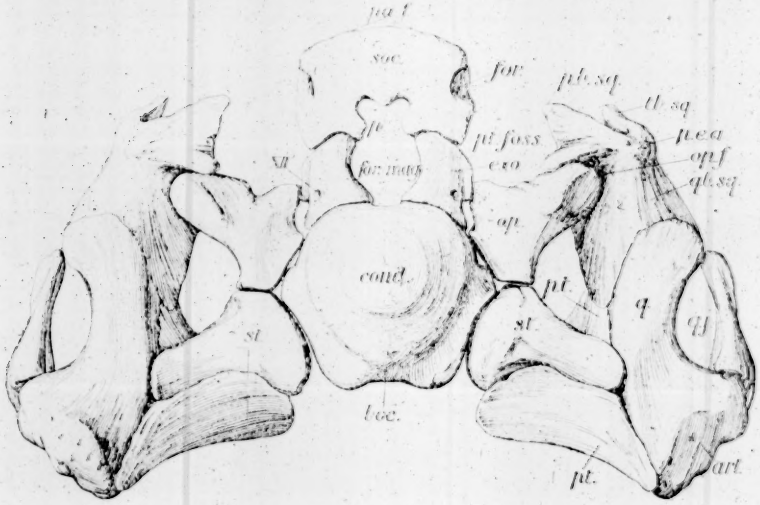


FIG. 2.—*Ophthalmosaurus icenicus*, Seeley. Reconstruction of the posterior surface of skull. About $\frac{1}{4}$ nat. size.

art. articular surface of quadrate; *bas.* basi-occipital; *cond.* occipital condyle; *exo.* exoccipital; *for.* foramen in supra-occipital; *for. magn.* foramen magnum; *op.* opisthotic; *op.f.* facet for opisthotic; *p.* process of supra-occipital projecting into foramen magnum; *pa.f.* facet for parietal; *p.h.sq.* parietal branch of squamosal; *p.e.a.* postero-external angle of squamosal; *pt.* pterygoid; *pt.foss.* post-temporal fossa; *q.* quadrate; *q.h.sq.* quadrate branch of squamosal; *q.j.* quadratojugal; *soc.* supra-occipital; *st.* stapes; *t.h.sq.* temporal branch of squamosal; XII. foramen for posterior branch of the hypoglossal nerve.

the opisthotics (*op.*), which internally rest upon the basi-occipital and the exoccipitals. The supra-occipital (*soc.*) consists of a lateral epiotic region, which is impressed by two of the semicircular canals, and a posterior occipital region, which is perforated on either side of the middle line by a large foramen (*for.*), which may have transmitted a blood-vessel or may possibly have something to do with the peculiarly modified auditory apparatus, and have served for the passage of an enlarged *ductus endolymphaticus*.

The other parts of the skull do not present any peculiarities of sufficient importance to be noticed here. The sclerotic ring consists of about fourteen plates, which are united by suture and bend round on to the posterior surface of the eyeball, as was pointed out by Owen[1] in *Ichthyosaurus* and recently by Gilmore[2] in *Baptanodon*.

[1] Foss. Rept. Liassic Form., pt. iii (Mon. Pal. Soc., 1881), p. 103.
[2] Mem. Carnegie Museum, vol. ii (1906), p. 328.

The vertebral column consisted of about 122 vertebræ. The centra of the atlas and axis are closely fused, and only in very young individuals are any clear indications of their original separation to be observed. Behind these are about thirty-eight vertebræ, which may be regarded as precaudal; these bear both parapophyses and diapophyses for the articulation of the ribs; these processes when followed from before backwards are found to descend on the side of the centra and approach till they finally unite on about the forty-first vertebra, which may be regarded as the first caudal; in a few cases this union may take place on one side one or two vertebræ further forward than on the other, there being two facets on one side and one

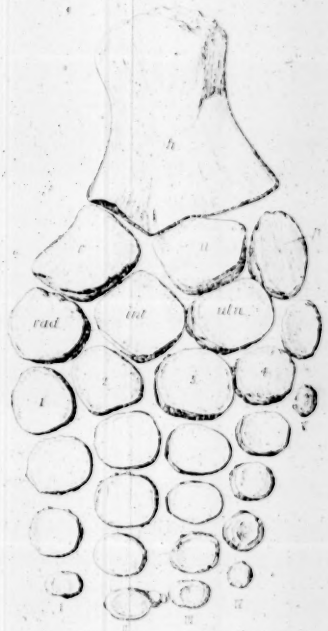


FIG. 3.—*Ophthalmosaurus icenicus*, Seeley. Ventral surface of right fore-limb. About $\frac{1}{3}$ nat. size.

h. humerus; *int.* intermedium; *p.* pisiform; *r.* radius; *rad.* radiale; *u.* ulna; *uln.* ulnare; 1–4, distal row of carpals; I–V, the five digits.

on the other in these centra. The caudals are about eighty-two in number; they bear single rib facets till just in front of the point where the column bends down into the caudal fin, and it appears that chevrons also were present in this region. A little in front of the bend above referred to the centra diminish very rapidly in size; they are also less definite in form and have rounded edges, probably because more flexion took place at this point than elsewhere. The bend itself is caused by the presence of five or six centra which are more or less wedge-shaped, being longer dorsally than ventrally. Behind the bend there may be as many as forty-eight vertebræ, the centra of which

are well ossified with sharply defined edges. The neural arches seem to have persisted to the extreme end of the tail, and there may have been very small chevrons also.

The neural arches of some of the anterior cervical vertebræ consist of two lateral pieces, and in this case the anterior and posterior zygapophyses are paired. Farther back the arch shows no trace of division into halves and the anterior and posterior zygapophyses unite to form single median facets.

The precaudal ribs are double-headed, their capitular and tubercular process being comparatively long. The body of the ribs is grooved longitudinally on its anterior and posterior surfaces, which must have added considerably to their rigidity. Only fragments of slender ventral ribs have been found.

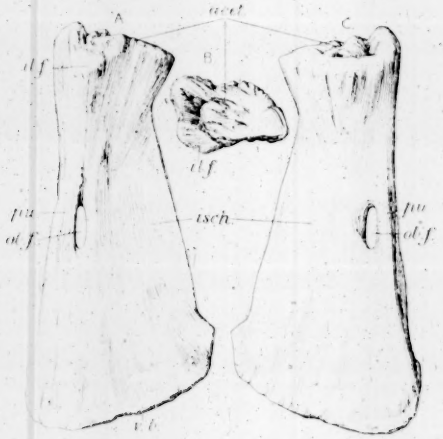


FIG. 4. *Ophthalmosaurus icenicus*, Seeley. Right ischio-pubic bone. A, upper (visceral surface); B, proximal articular end; C, ventral (outer) surface. About ¼ nat. size.

acet, acetabular surface; *ilf*, facet for ilium; *isch*, ischium; *obt.f*, obturator foramen; *pu*, pubis; *v.r*, ventral border.

The shoulder-girdle has been described and figured by Professor Seeley.[1] The coracoids are broad plates of bone, greatly thickened in their middle portion. Their posterior border is convex, while the anterior is concave owing to the presence of a wide, sharply defined notch. Internally the coracoids united with one another in a large cartilaginous symphysis; externally they bear a short anterior facet for union with the scapula and a much larger posterior cartilage-covered surface for the humerus. The scapula consists of a narrow dorsal blade and an expanded and thickened ventral region, which bears a facet for union with the coracoid, and behind this a small surface which completed the glenoid cavity in front. On the anterior border of the scapula is a roughened surface marking the line of union

[1] Quart. Journ. Geol. Soc. Vol. xxv. 1874, p. 686, pl. xiv. xlvi; also Proc. Roy. Soc. vol. lv. 1894, p. 181, fig. 1.

with the outer end of the clavicles. These are strongly curved bones, terminating externally in a point and uniting with one another in the middle line by an irregularly interdigitating suture, which may have been obliterated in advanced life. The upper surface of the middle portion of the clavicular arch is deeply channelled for the reception of the anterior bar of the T-shaped interclavicle, the posterior process of which extends back beneath the coracoid symphysis.

The fore-limb (Fig. 3, p. 205) is much larger than the hind, and forms a wide and powerful paddle. The humerus (*h.*) is a short and very

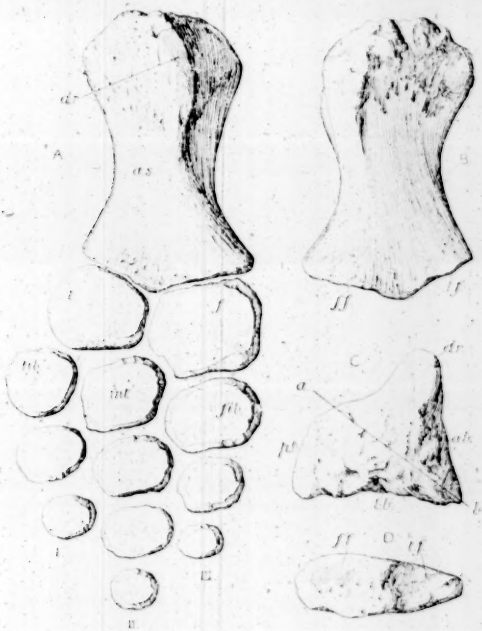


FIG. 5.—*Ophthalmosaurus icenicus*, Seeley. 15th hind-limb. A, dorsal surface of paddle; B, ventral surface of femur; C, proximal end of femur; D, distal end of femur. About $\frac{1}{4}$ nat. size.

a.b. anterior border of proximal end of femur; *a.s.* anterior surface of femur; *d.r.* dorsal ridge of femur; *f.* fenestra; *f.f.* facet for fibula; *fib.* fibulare; *int.* intermedium; *l.b.* lower border of proximal end of femur; *p.b.* posterior border of ditto; *p.f.* facet for tibia; *fib.* fibula; I–III, the three digits. In figure C the line *a* indicates the direction of the long axis of the distal end of the bone in relation to the proximal end.

stout bone, the distal end of which is expanded, and articulates with the radius (*r.*), ulna (*u.*), and to a varying degree with a postaxial element, usually recorded as the pisiform (*p.*). The proximal row of carpals consists of the radiale (*rad.*), the intermedium (*int.*), and the ulnare (*ulna.*). There are five digits (I–V), the postaxial one borne by the pisiform being much reduced. The paddle bones do not form a close mosaic as in most Ichthyosaurs, but seem to have been separated by a considerable amount of cartilage throughout life.

The pelvis and hind-limb are small and evidently undergoing reduction. The ilium is a sickle-shaped bone, thin above, but thickening towards its ventral end, where it bears two articular surfaces, one forming part of the acetabulum, the other uniting with the ischio-pubis; probably all connection with the vertebral column was lost. The pubis and ischium (Fig. 4) are fused with one another at their upper and lower ends, the line of separation being marked by a slit-like foramen (*obt.*), and sometimes by a notch in the ventral border. At the thickened upper ends of the combined bones there are two roughened surfaces, the smaller (*il.f.*) for union with the ilium, the larger (*acet.*) forming the greater part of the acetabulum; the two bones are so closely united at the upper end that even in very young examples it is impossible to determine what share in the formation of these facets is taken by each. Distally the bones are thin, and there is no clear indication that the opposite sides met in a median symphysis.

The femur (Fig. 5), though much smaller than the humerus, is on the whole very similar in form to that bone, with the important exception that it unites distally with two elements only, the tibia (*t.*) and fibula (*f.*). Of these the fibula is the larger, at least except in some cases in which the thin anterior edge of the tibia is fully ossified. The proximal row of carpals are three in number, the tibiale (*tib.*), intermedium (*int.*), and fibulare (*fib.*); the distal row also consists of three only, while the remainder of the tridactyl (I–III) paddle consists only of irregularly-shaped metatarsals and nodule-like phalanges.

The above account is merely a brief summary of the complete description which will be given in the Catalogue and illustrated with figures of most of the bones of the skull and skeleton.

IV.—Sedgwick Museum Notes.

New Fossils from Haverfordwest.—VII.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE VI.)

Sladina cateniformis, gen. et sp. nov. (Pl. VI, Figs. 1–7*a*, ? 8–9*a*.)

In the Slade Beds of Upper Slade there occur small flattened leaf-like bodies generally fused together in a linear series of 2–4, but sometimes singly. These fossils have a somewhat puzzling aspect, but they may be referred without any doubt to the Bryozoa, though to a new and undescribed genus and species.

Diagnosis.—Zoarium composed of a single linear row of leaf-like segments, each of which is usually lanceolate in shape, thin, flattened, and tapering anteriorly. The segments are generally graduated in size, and each is fused by its apex to the base of the one preceding it, but the terminal one, which is the smallest and narrowest of the series, ends freely in a point, and possesses a perfect lanceolate form. Each leaf is bilaterally symmetrical and unilaminar; the reverse face is slightly convex, ridged axially, and covered with a thin epitheca bearing a median longitudinal midrib continuous from leaf to leaf throughout the whole series in the zoarium; on each side of the midrib

are rather strong arched longitudinal striæ, indicating by their pointed lanceolate arrangement and invasion of the base of the preceding segment that the leaves overlap each other successively. There is occasionally a short stalk present in the basal and apical segments and paired lateral spines may be present. The celluliferous face of each segment is flat and shows the one layer of cells arranged in rather irregular rows diverging in a fan-shaped manner from the base; the median rows are more or less subparallel and continuous from leaf to leaf without a break, and are composed of short cells of equal size, very oblique to the surface; the lateral rows diverge more strongly to the sides and are irregular, and the cells are subequal in size, somewhat larger, shorter, and less oblique to the surface, so as to form a close polygonal mosaic; in a leaf 5 mm. long, 15–20 cells may be counted round each lateral margin, and 10–15 across the widest part of the leaf, the number varying with the size of the leaf, but the size of the cells remains fairly constant.

Dimensions:

		Length.		Width.
I.				
Basal leaf		4·75	...	3·00 mm.
Middle		4·00	...	2·75 mm.
Apical		3·00	...	1·50 mm.
II.				
Basal leaf (showing transverse constriction or compound nature)	posterior part	2·50	...	2·75 mm.
	anterior part	4·00	...	3·00 mm.
Middle leaf		3·75	...	2·75 mm.
Apical		2·25	...	1·25 mm.
III.				
Posterior leaf		5·25	...	4·25 mm.
Anterior		5·25	...	4·00 mm.

In No. II the basal leaf shows a transverse constriction which may indicate that it is composed of two almost completely fused leaves, or the constriction may be of a secondary nature, which would ultimately result in the division of the one leaf into two and thus increase the number of segments of the zoarium.

Isolated leaves: length, 4·0–5·0 mm.; width, 2·0–2·25 mm.

There are two other specimens (Pl. VI, Figs. 8–9*a*) which probably represent a variety or another and later stage of growth in the same species. One of these consists of a modified leaf of the same type as the foregoing, with the usual medianly ridged epitheca on one side and the radiating rows of cells on the other. But instead of being of a lanceolate shape, it is subrhomboidal and considerably broader than usual; the two longer sides meet at the apex at about 75°, and the two shorter ones at the base at rather more than a right angle; the base is produced into a short point, but the lateral angles are furnished with long straight tapering spines directed at right angles to the axis of the leaf, and marked by a median groove, but apparently not celluliferous. In length they are equal to about two-thirds the greatest width of the leaf. At the apex of the leaf we see attached in the usual way a very small slender lanceolate leaf of about half the length of the main one. Length of large leaf, 5·0 mm.; maximum width of ditto, 4·5 mm.; length of small leaf, 2·25 mm.

The other specimen (Pl. VI, Figs. 9, 9*a*) has a much less regular shape and appears to consist of three segments, all of which may be regarded as modified leaves. The lowest and largest one has an irregular elongated rhomboidal shape, angulated laterally near the base, as in the last described specimen, but not provided with spines; its base is somewhat produced, and its apex is broadly fused with a small lanceolate leaf of the usual type. The point of the latter is attached to the apex of an equilaterally triangular segment, provided at the extremities of its base with short stout grooved straight spines directed forwards, like horns. The whole series of three segments has the usual epitheca and continuous median ridge on one face, and on the other the customary arrangement of cells, which are even similarly developed on the peculiar horned triangular segment. Length of whole series to tip of spines, 15·0 mm.; length of lowest segment, 7·5 mm.; width of ditto, 4·25 mm.; length of second segment, 3·25 mm.; length of triangular segment (without spines), 3·25 mm.

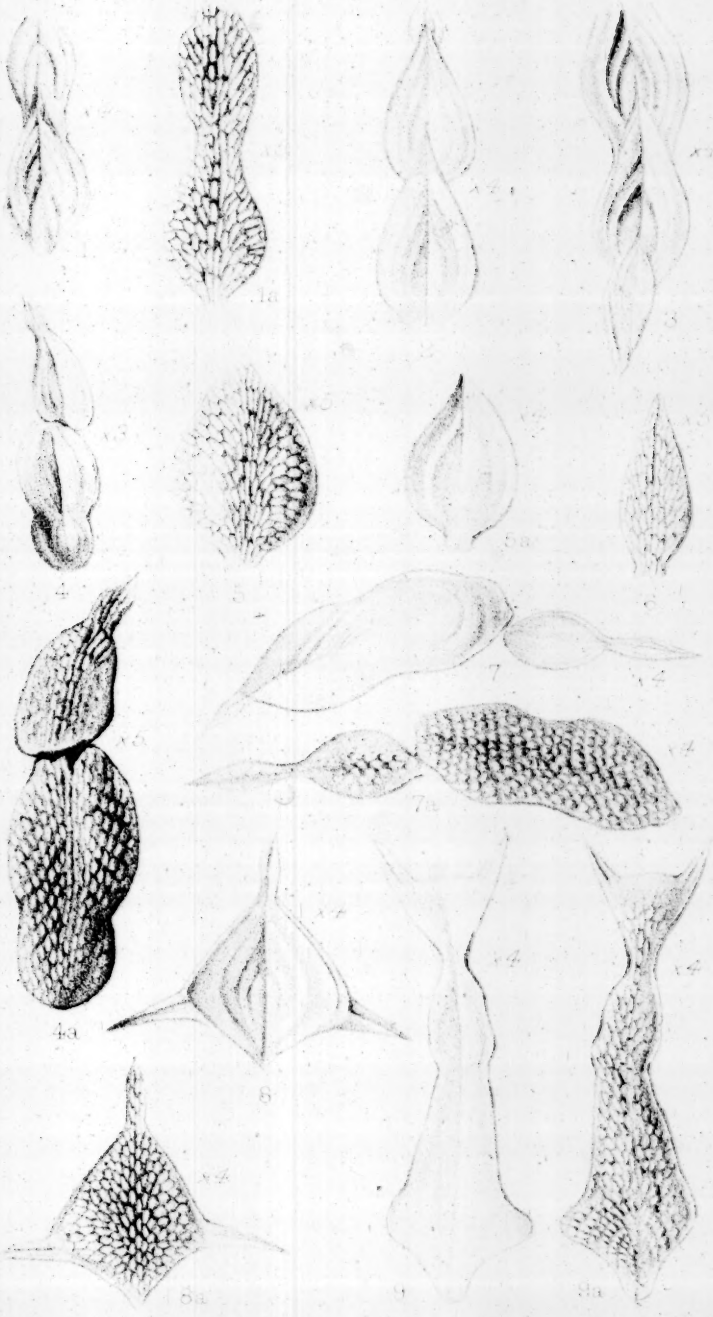
Affinities.—The structure of this peculiar Bryozoan reminds us in some respects of *Ptilodictya*, especially in the arrangement of the zoœcia, but it is unilaminar instead of bifoliate, and we are not sufficiently acquainted with the minute structure of the celluliferous surface or with the internal characters to press this comparison. The unilaminar and segmented nature of the zoarium, the peculiar epitheca, and the occasional presence of spinose processes, with a prevailing bilateral symmetry in all parts, prove that this Slade Bryozoan belongs to a new and distinct genus to which the name *Sladina* may be suitably applied. The chain of lanceolate segments of graduated sizes with the smallest segment at the top suggest apical growth of the zoarium. The multiplication of segments may take place by transverse constriction, if this is the correct interpretation of specimen II and similar ones. Whether the apical segments are naturally detached to form new zoaria or whether their occasional isolated occurrence is accidental must remain an open question for the present.

Definition of genus.—Zoarium unilaminar, composed of flattened lanceolate segments, attached in a straight line, with occasionally the apical one triangular and furnished with spines; the basal one also may be provided with a pair of lateral spines. Each segment is bilaterally symmetrical and is covered on one face by a thin medially ridged epitheca with growth-lines concentric to lateral margins. Celluliferous face closely set with zoœcia, arranged in 2–3 median rows (which are generally continuous through the whole chain of segments), with irregularly radiating rows of similar cells on each side, diverging in a fan-like manner to the lateral margins of each leaf. Type, *Sladina cateniformis*, Slade Beds, Upper Slade, Haverfordwest.

EXPLANATION OF PLATE VI.

NEW FOSSILS FROM HAVERFORDWEST.

FIG. 1. *Sladina cateniformis*, gen. et sp. nov. Reverse face. × 4.
,, 1*a*. Ditto. Same specimen. Celluliferous face. × 5.
,, 2. Ditto. Reverse face, showing three segments. × 4.
,, 3. Ditto. Reverse face, showing small basal segment. × 4.
,, 4. Ditto. Reverse face, with lowest segment showing transverse constriction. × 3.



New Fossils from Haverfordwest.

FIG. 4*a*. *Stadina catenaeformis*, gen. et sp. nov. Same specimen. Celluliferous face. × 5.
,, 5. Ditto. Isolated segment. Celluliferous face. × 5.
,, 5*a*. Ditto. Same specimen. Reverse face. × 4.
,, 6. Ditto. Isolated apical segment. Celluliferous face. × 5.
,, 7. Ditto. Reverse face of disjointed specimen. × 4.
,, 7*a*. Ditto. Same specimen. Celluliferous face. × 4.
,, 8. Ditto. Variety or later stage with lateral spines. Reverse face. × 4.
,, 8*a*. Ditto. Same specimen. Celluliferous face. × 4.
,, 9. Ditto. Variety with spined terminal segment. Reverse face. × 4.
,, 9*a*. Ditto. Same specimen. Celluliferous face. × 4.

V.—Recent Geological Information about Blackheath.

By T. V. Holmes, F.G.S.

(WITH A MAP.)

A GLANCE at a geological map shows Blackheath and Greenwich Park at the western end of the Lower Tertiary escarpment which is conspicuous on the southern side of the Thames as far eastward as Erith.

This escarpment has the Chalk visible here and there at its base. Above the Chalk comes the Thanet Sand, then the Woolwich Beds, while the plateau is capped by the Blackheath Beds. Around Shooters Hill the London Clay comes on above the Blackheath Beds, and is itself capped at Shooters Hill by gravel of later date. At Blackheath the surface is composed of the Blackheath Pebble Beds. But before mentioning the recent workings there, it is necessary to recall events which took place between twenty-five and thirty years ago on that well-known Common.

On Thursday, April 12th, 1878, after a night of very heavy rain, it was found that at the spot marked A on the map, south of the Shooters Hill Road, and north of that between the south-west corner of Greenwich Park and Morden College, a subsidence had occurred. This, after some little delay, was filled up by the Metropolitan Board of Works. Early in November, 1880, another appeared some distance south-west of the first (B), and on November 19th a third, not far from the first, marked on the map as C. As regards shape, they all agreed in being considerably wider at the bottom than at the top. But that at B was shallower, and widened at the bottom to a greater extent than the two other holes. A and C were almost perfectly identical in shape and depth, and were less than 150 yards apart. Of B I have nothing more to say than that its broader and shallower form suggested a distinction of some kind which made the amount of its affinity to A and C uncertain. In the *Engineer* of February 4th, 1881, sections are given of B and C. The size and shapes of A and C are both described in the account given in the *Engineer* of the last-named pit. It is said to have been almost circular in shape, "being 7 ft. 8 in. in the longest diameter and 6 ft. 9 in. in the shortest. The sides went down vertically to a depth of 18 feet, and had all the appearance of a well or artificial shaft. At the bottom was a heap of fallen earth, and when this was removed the sides were found to recede, the hole increasing in its diameter to about 14 feet."

The Lewisham and Blackheath Scientific Association (a then newly formed local scientific society) raised a fund from residents in the neighbourhood for the exploration of pit C, and appointed a committee to superintend the work.[1] From this committee an executive sub-committee was selected, consisting of Sir G. B. Airy, Dr. H. E. Armstrong, W. H. Bond, E. W. Brabrook, T. V. Holmes, H. W. Jackson, Rev. Brooke Lambert, J. K. Laughton (chairman), J. E. Price, Dr. Prior Purvis, Rev. T. Wiltshire, and John Yeo. The hole was timbered and the work began. At a depth of about 34 feet from the surface water appeared, and became more and more troublesome as the depth increased. From the report drawn up by the Chairman we learn:—

"The ground, which was continuously sand more or less mixed with water-worn rounded stones, varying in size from a marble to a cricket ball, was throughout broken and disturbed; it yielded readily to the spade, and the pickaxe was at no time called into requisition. The earth behind the timber was thus all alive; it had no cohesion of itself, and transmitted the pressure to the timbering almost as if it had been fluid. When the weight and liveliness of the water was added to that of the sand this effect was intensified, and apprehensions began to be entertained lest the timbering should be found of insufficient strength."

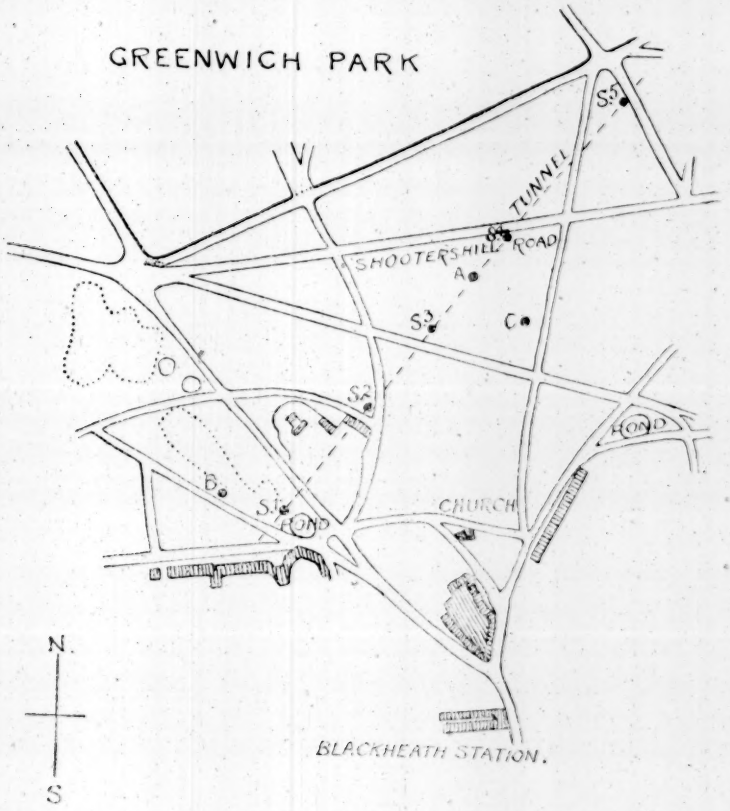
At a depth of 43 feet there was an inequality of vertical resistance, which caused the timber framework to 'cant' and 'long-corner.' This tendency increased, and combined with the difficulty arising from the inflow of water to stop further excavation, owing to the great difficulty and expense which would attend it. So it was resolved to drive an iron tube down, to test the hardness or softness of the material, and to ascertain the existence of any cavity. Two tubes were driven down; the first was withdrawn after having sustained a fracture, the second was driven to a depth of 84 ft. 6 in., but was there stopped by some hard mass, which it could neither pierce nor thrust aside. The first pipe was easily drawn up; the second only with the utmost difficulty, though the track of each was almost perfectly identical. As the second was being withdrawn specimens of the earth at the bottom were obtained by means of a small scoop attached to the end of a rod passed down the pipe, and these samples testified to the abnormal condition of the strata passed through.

We read:—"Down to about 50 feet they are sandy; but from that to the bottom are clayey, and more clayey as the depth increases. But a comparison with the known stratification of the district shows that from 35 to 50 feet or thereabouts, is the level of the clayey beds; that below that is the Thanet Sand; and it is therefore conjectured that the fine peculiarly greasy clay brought up by the scoop from the depth of 84 ft. 6 in. may have been washed down when the shaft, no longer used, was suffered to fall in."

Accounts of subsidences in other districts, supposed to be analogous in some way to those at Blackheath, were sent in to the Committee,

[1] The Lewisham and Blackheath Scientific Association (like so many local scientific societies) was short-lived, and came to an end in 1893. Hence it seems desirable to give a more detailed account of its work here than would otherwise be the case.

who also consulted several distinguished geologists, archæologists, and engineers. Professor Prestwich and Mr. W. Whitaker both inclined to think the cause of the subsidences not purely geological, and Mr. F. C. J. Spurrell thought them the result of the existence of dene-holes at the spots where they occurred. The Committee, as a body, felt unable to accept any view as conclusive. Being myself a member of the Committee, and having a decided view on the matter, my colleagues were good enough to append my remarks to the report. They were to the effect that no purely natural action



of water under Blackheath on the Chalk was at all probable, owing to the presence of the more or less clayey beds of the Woolwich Series, which prevented water percolating through the pebble beds at the surface from ever reaching the Chalk. But that, granting the existence of deep shafts from the surface ending in chambers in the Chalk (like that described by Mr. Flinders Petrie as existing at Eltham), the Blackheath subsidences were easily explained. For a disused and neglected shaft would naturally become more and more

enlarged about that part at which water tended to enter, the material washed down, filling the chamber below and the lower part of the shaft. At last the cavity would become too large for stability, and the result would naturally be a subsidence at the surface taking the shape of that at pits A and C. Hypothetical sections illustrating these changes were added to my remarks appended to the report of the Exploration Committee.[1]

I now turn to events at Blackheath of a much more recent date. During the last year or two enclosures were made at intervals on Blackheath from a spot close to the "Hare and Billet" public-house, near Blackheath village, to the north-eastern corner of the heath close to the Charlton Road. They marked the positions of the shafts sunk along the course of the main drainage tunnel constructed in the Chalk beneath Blackheath. It soon became evident that the line taken by the tunnel, as indicated by the positions of two of these shafts, was such as to pass vertically beneath the site of the subsidence at A, which was, as already stated, precisely similar in size and shape to that at C, in which the Exploration Committee worked in 1881. Accordingly I wrote to Messrs. S. Pearson & Son, Ltd., the contractors, mentioning my interest in subterranean Blackheath, and expressing a desire for information as to their experience of it. My request was most kindly granted, and I am much indebted to a member of the firm, Mr. B. C. Cass, for the following additions to our knowledge of the geology of Blackheath.

Between a spot a few yards northward of the pond close to the "Hare and Billet" and another not far from the south-eastern corner of Greenwich Park there are five shafts along the line of the drainage tunnel. The shaft here called No. 1 is that near the "Hare and Billet"; No. 2 is close to but eastward of Talbot Place; No. 3 is close to but on the northern side of the road between the south-western corner of Greenwich Park and Morden College; No. 4 is near but south of the Shooters Hill Road; and No. 5 is about 70 yards southward of the south-eastern corner of Greenwich Park. The course of the tunnel is thus from south-west to north-east, and the portion of it which runs beneath the site of the subsidence at A is between shafts 3 and 4. As regards the depth at which water was met with during the sinking of these shafts, Mr. Cass gave me the following information:—

Shafts.	Depth at which water was found.	Height of surface above ordnance datum.
	ft. in.	feet.
1	24 6	140
2	32 0	150
3	no water	150
4	32 0	146
5	32 0	147

He added that this water, which, percolating through the Blackheath Pebble Beds, is upheld by the more or less clayey beds

[1] These sections, reproduced from the report, may be seen in the "Record of Excursions" of the Geologists' Association, pp. 5–8. They were introduced there to illustrate a very short report of an excursion to Charlton, Blackheath, and Lewisham conducted by Mr. J. Logan Lobley on April 30th, 1881, during which the subsidence at C was visited. The exploration was then in progress.

of the Woolwich Series beneath, nowhere formed any serious obstacle to making the shafts. As regards shaft 3, in making which no water appeared, Mr. Cass stated that it was sunk some months later than Nos. 1 and 4, which were almost finished when No. 3 was begun. The details of the sections in shafts 2, 3, and 4 are here given:—

Shaft No. 2.

		Thickness. ft.	in.	Depth. ft.	in.
Blackheath Pebble Beds.	Soil	1	0	1	0
	Loamy gravel	24	0	25	0
	Yellow loamy sand	9	6	34	6
	White sand	4	6	39	0
Woolwich Beds.	Shell deposit	1	9	40	9
	Blue clay	3	9	44	6
	Pebbly sand	2	0	46	6
	Blue clay	0	6	47	0
	Loamy sand and pebbles	6	0	53	0
Thanet Sand.	White sand	48	6	101	6
	Black sand and flints	1	0	102	6
Chalk.	Bottom of shaft 123 ft. 3 in.				

Shaft No. 3.

		Thickness. ft.	in.	Depth. ft.	in.
Blackheath Pebble Beds.	Soil	1	0	1	0
	Loamy gravel	9	0	10	0
	White sand	23	0	33	0
	Loamy sand	5	0	38	0
Woolwich Beds.	Shell deposit	1	0	39	0
	Loamy sand	0	9	39	9
	Shell deposit	1	9	41	6
	Yellow clay	3	9	45	3
	Hard mixture of clay, sand, and pebbles	7	9	53	0
	Green sand	0	9	53	9
Thanet Sand.	White sand	48	9	102	6
	Black sand and flints	1	0	103	0
Chalk.	Bottom of shaft 123 ft. 3 in.				

Shaft No. 4.

		Thickness. ft.	in.	Depth. ft.	in.
Blackheath Pebble Beds.	Soil	0	6	0	6
	Dirty ballast	9	6	10	0
	Yellow clay	1	6	11	6
	Ballast	4	6	16	0
	Loamy sand	8	0	24	0
	White sand	1	3	25	3
Woolwich Beds.	Loamy sand	5	8	30	11
	White sand	7	6	38	5
	Red sand	2	3	40	8
	White sand	4	9	45	5
	Hard mixture of clay, sand, and pebbles	4	0	49	5
	Green sand	3	0	52	5
Thanet Sand.	White sand	48	1	100	6
	Black sand and flints	1	0	101	6
Chalk.	Bottom of shaft 119 ft. 9 in.				

If we compare the sections in these three shafts, we find that while the Thanet Sand is of the same thickness and character in each, and there is nothing peculiar in any of them as regards the Blackheath Beds, the Woolwich Beds are nearly alike in shafts 2 and 3 and differ noticeably from those of No. 4. On noting the absence of any "shell deposits" in the Woolwich Beds of No. 4, I wrote to Mr. Cass asking

if they were non-existent in that shaft; for the word '*ballast*' being used for *gravel* in that section only, suggested a different reporter of the strata in that case. In reply Mr. Cass remarked:—"In No. 4 pit we did not come across any of the shell deposits as we did in Nos. 2 and 3. No. 4 was very free from shells, only very few being found in the sands." And as regards the spot between shafts 3 and 4 at which the tunnel passed beneath the hole formed by subsidence A on April 12th, 1878, Mr. Cass informed me that at a depth of about 120 feet the chalk there was found to be all broken up and mixed with material of various kinds which had fallen from above.

I have already alluded to the deep shaft ending in a chamber in the Chalk discovered at Eltham. Early in the year 1878 there was a leakage in the water-supply at Eltham Park, the seat of Mr. T. Jackson, about three miles from Blackheath. A disused brick drain, being opened up, was found to end at the top of a shaft 4 feet in diameter and 140 feet deep, at the base of which was a chamber in the Chalk, the extreme dimensions of which were 40 by 63 feet and the height 9½ feet. The lowest 22 feet of the shaft were cut through the Chalk, and it was lined throughout with courses of brick and chalk. Mr. Flinders Petrie read a paper describing it at a meeting of the Royal Archæological Institute on March 1st, 1878, from which these details are taken. At some period much later than that of its original construction, the chamber had been utilised as a cesspool, for a period, Mr. Flinders Petrie thinks, of "at least a century, perhaps two or three centuries." As to the objects of its makers, he finds no suggested explanation satisfactory. On that point I would only add that it seems evident that it must have been made for the sake of the chamber, and not for that of the material extracted therefrom, and consequently that it belongs to the dene-hole class.

The beds traversed by the shaft at this Eltham pit are the same as those at Blackheath. The Thanet Sand was 52 feet thick at Eltham, the Woolwich Beds 26 ft. 3 in., and the Blackheath Beds 37 ft. 9 in.: the top of the Chalk being 116 feet below the surface there, instead of 101 ft. 6 in. to 103 feet, as found near the sites of the Blackheath subsidences A and C. And while the nature of the beds composing Blackheath would be unusually easy to recognise in primitive times, as they are more or less visible close by, on the slopes of the Lower Tertiary escarpment, both northward and westward, there are no similar helps to observation at Eltham.

We have seen that the exploration of the subsidence at C, in 1881, showed that the strata vertically beneath were much shattered and mixed together, greasy clay being obtained at a depth of 84 ft. 6 in., where the Thanet Sand exists in undisturbed ground. And the course of the recent tunnel beneath the subsidence at A indicated that the Chalk there at a greater depth was broken up and mixed with other material from above. In addition we know that the appearances presented by both those subsidences at the surface were practically identical, their vertical sides suggesting shafts, while the expansion, beginning at a depth of about 18 feet from the surface, would be the natural result of the action of the water met with at a depth of

32 feet in the recent shafts) on shafts disused and neglected for centuries. And of course this expansion, when it became too great for stability, would ultimately produce subsidences at the surface such as were once visible at A and C.

It may perhaps seem disappointing, at first, that something approximating to the discovery at Eltham in 1878 was not the result of the course taken by the recent tunnel beneath the site of the subsidence at A. But at Eltham the chamber in the Chalk was preserved because the shaft leading to it was preserved. It had escaped destruction through the exceptional circumstances that it had been utilized, in some way or other, centuries after the purposes of its originators had been forgotten. But in the case of the disused and neglected pits at Blackheath, the surface subsidences implied the simultaneous destruction of all that had up to that time remained of shaft and chamber below. The evidence afforded by the recent tunnel therefore confirms, as strongly as circumstances allow, the hypothesis that these Blackheath subsidences mark the sites where once existed shafts with chambers in the Chalk below, like the pit at Eltham.

Note.

This seems to be a good place for the introduction of the following brief acount of a Blackheath subsidence in the year 1798. It is from the *Gentleman's Magazine* for that year, p. 1078:—

"Nov. 19. A singular accident happened last week at Blackheath. As a farmer and his son were conversing together in a field where a horse was feeding, on a sudden the animal sunk into the earth (hind feet first) to the depth of 15 feet, out of which he was dug, crushed to death. The cavity was only just sufficient to admit his body, the surrounding soil remaining firm."

This certainly suggests a subsidence resembling those at A and C. But its scene must have been a little east, or north-east, of the common now known as Blackheath.

VI.—Plant Remains in Basalt, Mexico.

By Dr. M. M. Solórzano, of the Museo Michoacano, Morelia, Mexico, and Bernard Hobson, M.Sc., F.G.S., of the University of Manchester.

(PLATE XI.)

WHEN the members of the "Jorullo Excursion"[1] of the Tenth International Geological Congress were in the city of Morelia, in Mexico, they visited the College of St. Nicholas (founded in 1540), in the buildings of which is the Museo Michoacano. One of the most interesting objects in the Museum in question is a piece of basaltic lava containing remains of maize, which has been described by Dr. M. M. Solórzano, the Curator of the Museum, in an article entitled "Breve noticia acerca de algunos productos volcánicos de las inmediaciones de esta ciudad" in the "Boletín de la Sociedad Michoacana de Geographia y Estadistica," Tomo ii, Núm. 8, Morelia, Julio 15 de 1906, pp. 59, 60.

[1] See Geol. Mag., 1907, p. 5.

The following is a translation of the last two paragraphs of the article: "To conclude these short notes, I will mention another volcanic product which, although it does not [1] occur in the environs of this city as do those previously described, is exceedingly interesting, since it proves not only the small conductivity of lavas in spite of their very high temperature, but also indicates, to a certain extent, the epoch in which volcanic phenomena were in full activity in the region where the rock I refer to was collected."

"This specimen, which is exhibited in the Museum before mentioned [Museo Michoacano], awakened the interest of that expert geologist and engineer, Mr. Ezequiel Ordóñez. It is a basaltic scoria which was collected [at the Hacienda de la Magdalena, distant only some $4\frac{1}{2}$ leagues ($11\frac{3}{4}$ English miles) from this city, and at a very short distance from the volcanic Pico de Quinceo],[2] and shows numerous and very distinct external impressions of female ears of maize and also entire grains and carbonized remains of the axis of the ear. (See Plate XI.) This seems to show that the inhabitants of the locality in question cultivated the plant just mentioned when a volcano [one of the extinct ones which exist between Quiroga and Patzcuaro][3] made the eruption which ejected the rock above described."

It is of interest to recall other occurrences of plant-remains in basalt. J. Macculloch[4] described and figured an erect coniferous tree in basalt at Gribon, Isle of Mull, which has subsequently been referred to by Mr. J. Starkie Gardner,[5] and illustrated from a photograph in Sir A. Geikie's "Scenery of Scotland" (3rd ed., 1901, p. 142).

Mr. H. M. Cadell[6] has described the remains (12 inches long) of a Lycopod stem in basalt at Cowdenhill, Grangepans.

Mr. J. D. Dana, describing the Kilauea (Sandwich Islands) lava of the 1840 eruption, says:[7] "The rapidity with which lava cools is still more remarkably shown in the fact that it was found sometimes hanging in stalactites from the branches of trees; and although so fluid when thrown off from the stream as to clasp the branch, the heat had barely scorched the bark." Describing the Kilauea eruption of 1868, he remarks:[8] "As has happened in most Hawaiian eruptions, trees were enveloped by the lava-flood. Half-charred trunks were standing in 1887 with a rough cylindrical encasement of lava about the stumps."

Mr. J. S. Diller[9] has described a tree pushed over by the advancing lava stream of the Cinder Cone, 10 miles north-east of Lassen Peak, and gives a plate (No. xiv) showing the tree in the lava.

[1] In view of the correction mentioned below the "not" should be omitted.

[2] This is the correct locality according to a letter of November 3rd, 1906, from Dr. Solórzano to me. The printed account states "in the vicinity of Quiroga, District of Morelia."

[3] This is incorrect owing to the true locality being different.

[4] "A Description of the Western Islands of Scotland," etc.: vol. i (1819), p. 568.

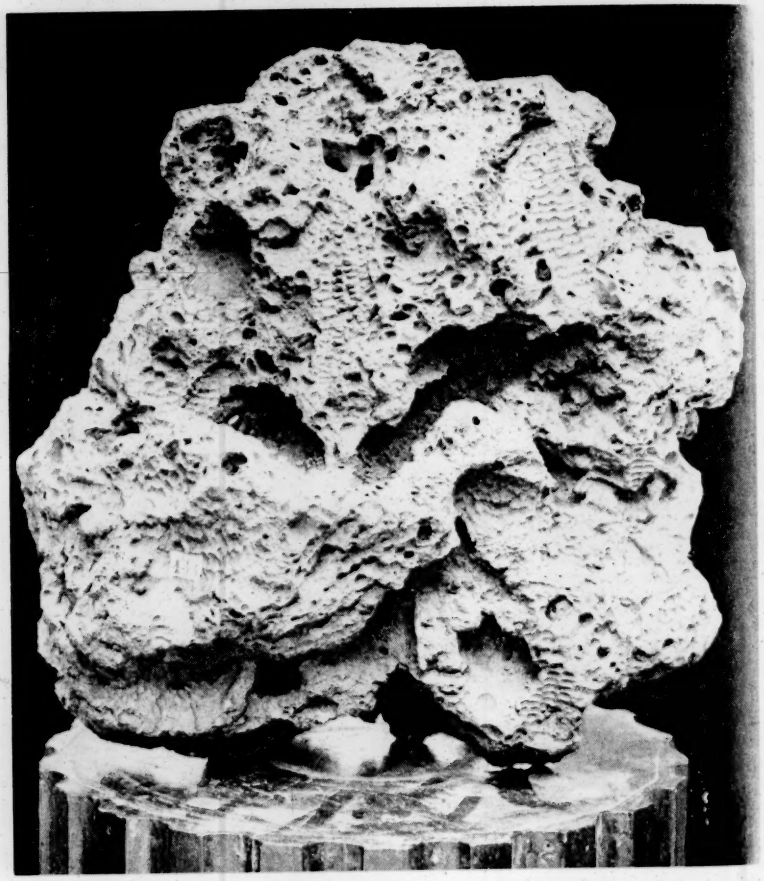
[5] Quart. Journ. Geol. Soc., 1887, p. 283.

[6] "The Occurrence of Plant Remains in Olivine Basalt in the Bo'ness Coalfield": Trans. Geol. Soc. Edin., vol. vi (1892), pp. 191–193, pl. vi. (See *infra*, p. 219.)

[7] "Characteristics of Volcanoes," etc.: 1890, p. 64.

[8] Loc. cit., p. 91.

[9] "A Late Volcanic Eruption in Northern California and its peculiar Lava": Bulletin No. 79, U.S. Geol. Survey, 1891, p. 20.



Remains and Impressions of Ears of Maize in Basalt, More
Mexico.

Slightly less than one-third linear of the size of the original specimen.

The late Mr. F. A. Fouqué, describing some phenomena observed on Etna, says[1] (trans.): "The lava of the 1865 eruption flowed through the midst of a wood of lofty trees. . . . Many trees had been torn up or burnt. Nevertheless, a great number of them remained standing on each side of the fissure, in spite of the movements of the ground and in spite of the incandescent current which had for a moment surrounded them. The trees thus preserved were all, without exception, surrounded by a stony sheath formed of solidified lava. The interior surface of this sheath had moulded itself on the surface of the tree, of the bark of which it sometimes reproduced all the details with surprising fidelity."

Mr. R. H. Walcott[2] has described a pseudomorphous replacement by solid basalt of a tree 10 feet high with a branch and roots. The stem has an average circumference of 31 inches: "The surface bears a number of corrugations and has the identical appearance of bark." "The surrounding basalt comprising the mould in which the tree was formed, judging from the two available pieces, is to all appearances of the same nature as the cast." The cast was found in a quarry at Footscray (which appears to be close to Melbourne).

DESCRIPTION OF PLATE XI.

The photograph shows the piece of scoriaceous basalt preserved in the Michoacan Museum, Morelia, Mexico. The specimen measures 12·09 inches in height, 13·26 in width, and 7·60 in thickness (front to back). Impressions of ears of maize are shown on the right (*a*) just below the right upper corner, (*b*) towards centre of margin overhanging a cavity, (*c*) at the two right bottom corners; but the most striking example is just above the two converging central cavities, where an ear in a vertical position shows not only impressions but actual grains of maize. Several other impressions occur, but are indistinct in the plate. The figure is slightly less than ½ linear of the size of the original specimen.

[In connection with the foregoing note on Plant-remains in Basalt from Mexico, the subjoined observation by Mr. H. M. Cadell, B.Sc., F.R.S.E., reprinted from the Trans. Geol. Soc. Edinb., vol. vi (1892), pl. xi, pp. 191–193, deserves to be recorded here.—Edit. Geol. Mag.]

VII.—The Occurrence of Plant Remains in Olivine Basalt in the Bo'ness Coalfield.

By Henry M. Cadell, B.Sc., F.R.S.E.

(PLATE XIV.)

IN a paper which I read before the Edinburgh Geological Society on 26th January, 1880, and which appears in the Transactions, vol. iii, pp. 304–325, a general stratigraphical account is given of the extensive series of interbedded volcanic rocks of the Bo'ness Coalfield in Linlithgowshire.

[1] "Sur la non-altération des couches de houille en contact avec des roches éruptives": Bull. Soc. géol. France, ser. ii, vol. xxiii (1866), pp. 190–193.

[2] "Note on a Basalt Tree Cast": Proc. Roy. Soc. Victoria (Australia), new series, vol. xii, pt. 2 (1900), pp. 139–144, pl. xiii.

[3] The block for Plate XIV has been obligingly lent by the author, Mr. H. M. Cadell, F.R.S.E.

Some new facts of considerable geological interest have since been elicited in the course of mining and quarrying operations in the district. Among these the most remarkable is perhaps the discovery of undoubted fragments of plants in some of the sheets of basalt interstratified with the Carboniferous beds. In my former paper I referred to the occurrence of coniferous wood in some of the ash beds and neck tuffs that belong to the old volcanoes of the Carboniferous Limestone Series of Linlithgowshire, but such plant-remains, although interesting, are not particularly remarkable or surprising in their mode of occurrence, as similar remains have been found elsewhere, and their origin is not at all difficult of explanation.

The plant-remains I shall now briefly describe were found under much more unusual circumstances, and I may safely say that very few, if any, similar cases have been discovered in this country at least, in which the matrix surrounding the fossil consists of a crystalline massive volcanic rock.

During the Summer of 1890 I had occasion, while carrying out some improvements at Cowdenhill, in the village of Grangepans, to remove part of a knoll of trap that forms a low cliff on the south side of the public road. The trap in question is the bed that lies in this part of the Bo'ness coalfield, about 30 feet above the seam known as the Red Coal. It dips westward from its outcrop at Cowdenhill, and has been pierced in No. 3 Pit of Grange Colliery about 80 yards further west, where it has a thickness of about 27 feet. That the rock is contemporaneous and not intrusive is clearly proved from the fact that (1) it has never been found to cut across the strata in the many sections where it has been laid bare; (2) the beds below are slightly indurated at places, while those above are unaltered; (3) the upper surface is highly amygdaloidal and usually somewhat decomposed.

Where the excavation was made there is no means of ascertaining the distance from the top or bottom of the trap, but the rock is here quite solid and free from amygdules, and less decomposed than it usually is near the edges, so that the specimen to which I shall now refer was probably taken from near the centre of the old lava bed.

When first it was brought to light I took it for some species of mineral concretion, but a little examination soon proved that this could not be the case, as it not only looked remarkably like a lycopod stem, but was surrounded by a thin film of what appeared to be black carbonaceous matter. My friend Mr. R. Kidston, F.R.S.E., F.G.S., who kindly examined it and took the photograph which is reproduced in the accompanying plate (Pl. XIV), reports as follows:—

"The specimen, which is preserved in greenstone (basalt), is 12 inches long. The upper extremity is about 1½ inch in diameter, and owing to a fracture in the stone which contains the fossil the upper 3 inches are broken off and lift out of the matrix. In section the stem at this part is slightly compressed on one side. The lower extremity measures 2 inches in its greatest diameter, but it is also slightly compressed. About 4 inches from the base a branch has been given off on the left side of about equal size to the stem preserved, but only its truncated base is left to indicate its position.

Plant-remains in Basalt, from the Boʻness Coalfield, Linlithgowshire.

The fossil lies on the angle ridge of a rudely four-sided block, whose shape is determined by the natural jointing of the basalt, and, like the exposed surfaces of the stone, is stained an ochreous brown colour. With the exception of this very thin coating of iron oxide, and perhaps a little carbonaceous matter mixed with it, the original plant in its upper part is entirely replaced by crystalline calcite, as shown at the fracture in the specimen to which reference has already been made.

"The broken base (which only in part shows a fresh surface) appears to consist of lime and matrix intermingled, but this may not be more than a coating at the broken end.

"There cannot remain the slightest doubt that the fossil is part of a *Lycopod* stem. Its outer surface might be described as an imperfectly preserved specimen of *Knorria*, which, however, may have originated from a *Lepidodendron* or a *Lepidophloios*.

"The great interest of the specimen centres in the matrix in which it is preserved. The occurrence of a plant preserved in basalt is perhaps unique. The fossil was probably first reduced to a condition of 'charcoal' by the heat of the lava—a condition in which specimens are frequently found in volcanic ash—and subsequently the carbon has been removed and the cavity filled up by infiltrated lime."

I had some of the most carbonaceous-looking parts sliced for the microscope, but a close examination failed to show any traces of vegetable structure.

A microscopic examination of the rock, which Mr. J. G. Goodchild, F.G.S., has been kind enough to make, shows it to present the character of a medium-grained, hemicrystalline aggregation of (1) lath-shaped crystals of plagioclase, apparently labradorite, forming quite three-fifths of the mass; (2) a small quantity of a mineral too much decomposed to be recognizable, but which may have been one of the pyroxenes; (3) large grains of serpentinised olivine of characteristic form and optical properties; (4) magnetite in small grains and crystals, evidently representing the oldest crystallization; (5) more or less interstitial matter, which remains dark through a complete rotation under crossed nicols, and which must, therefore, represent undifferentiated matter that originally existed as glass. The presence of olivine, which is even more abundant than that in the olivine basalt of the Lion's Haunch (Arthur's Seat), along with abundant plagioclase felspar and a ground-mass, shows the rock to be an olivine basalt.

In conclusion, it is interesting to reflect that had such a discovery been made three-quarters of a century ago, when the Huttonian and Wernerian controversy was at its height, it would doubtless have been triumphantly adduced as a proof of the correctness of the Neptunists' view that greenstone and trap are rocks of aqueous sedimentary origin, in which organic remains might reasonably be expected to occur.

VIII.—The Fauna of the Bokkeveld Beds.

By F. R. Cowper Reed, M.A., F.G.S.

(Concluded from the April Number, p. 171.)

THE conspicuous relations of the brachiopod fauna of these beds to that of the Lower Devonian in South America have frequently been pointed out, and may be summarised as follows:—

1) In the Falkland Islands the following South African species are found (12):—

Chonetes falklandicus.
Orthothetes Sulivani.
Strophocladia concinna.
Leptocælia flabellites?
Spirifer antarcticus.
Cryptonella Bainii.
Orbiculoidea Bainii.

2) On the South American continent the following identical or allied species occur:—

South Africa.	South America.
Lingula aff. *densa*	*Lingula Cahuni*, Ulr. B.
Orbiculoidea Bainii	*Orb. Bainii*. Br. *Discina* sp. α, Ulr. B. *Orb.* cf. *humilis*, Hall. A., Br.
Strophonella sp.	*Strophonema* sp. β, Ulr. B.
Orthothetes Sulivani	*Orth. Agassizi*, Hartt. Br. *Orth.* sp. α, Ulr., B.
Chonetes falklandicus	*Ch. Comstocki*, Hartt. Br. *Ch. Rueki*, Ulr. B. *Ch. falklandicus*. A., Br.
Ch. cf. *Arcei*	*Ch. Arcei*, Ulr. A., B.
Ch. cf. *coronatus*	*Ch. coronatus*, Conr. A.
Orthis sp. ?	*Orthis* sp. β, Ulr. B.
Leptocælia flabellites	*Lepto. flabellites*, Conr. A., B., Br.
Vitulina pustulosa	*Vit. pustulosa*, Hall. A., B., Br.
? Trapezidetus carinatus ...	*Trap. carinatus*, Conr. B., Br.
Retzia cf. *Adriani*	*Retzia ? wardiana*, Hartt & Rath. Br.
Trigeria ? simplex	*Rhynchospira ? jamesiana* (Hartt). Br.
Rhynchospira ? Silveti	*Rh. ? Silveti*, Ulr. B.
Scaphiocælia africana	*Scaph. boliviensis*, Whitf. B.
Cryptonella Bainii	*Crypt. Riskowski*, Ulr. B.
Cryptonella? sp.	*Orthisina uncicella*, Hall & Clarke. Br.
Spirifer antarcticus + *Orbignyi*	*Sp. antarcticus*, M. & S. A. *Sp. Chiquisaca*, Ulr. B., Br. *Sp. huarguanus*, Rath. Br.
Sp. Ceres	*Sp. lauro-salvianus*, Katz. Br.
Sp. cf. *pedroanus*	*Sp. pedroanus*, Hartt & R. Br.

B. = Bolivia; Br. = Brazil; A. = Argentina.

It is noteworthy that no members of the genera *Rensselæria* or *Ptychospira* have so far been recorded from South America.

Ulrich (16) was the first to remark upon the affinities of the South African brachiopods of the Bokkeveld Beds to those of the Hamilton Group in North America, and especially referred to *Leptocælia flabellites* and *Vitulina pustulosa*. The following allied or identical species have so far been noticed as occurring in the North American Devonian:—

South Africa.	North America.
Lingula aff. *densa*	*Lingula densa*, Hall. Hamilton.
Orbiculoidea Bainii	*Orb. humilis*, Hall. Marc. and Ham.
Strophonella cf. *concinna* ...	*Stroph. perplana*, Conr. Up. Held. Chemung.

Strophonella sp.	*Stroph. ampla*, Hall. Up. Held.
Orthothetes Saltcani	*Orth. chemungensis*, Conr. Chemung.
Chonetes cf. *coronatus* ...	*Ch. coronatus*, Hall. Ham.
Ch. aff. *setiger*	*Ch. setiger*, Hall. Marc. Waverly.
Orthis sp.?	*Orthis lepida*, Hall. Ham.
Rhynchonella sp.?	*Rh. Hoffordi*, Hall. Marc. and Ham.
Rensselaria sp. α. Reed (? = *R. reflecta*, Schwarz) ...	*R. ovoides*, Eaton. Oriskany.
R. sp. β. Reed	*R. Cumberlandiæ*, Hall. Oriskany.
Trigeria aff. *Gaudryi* ...	*Trigeria Gaudryi*, Oehl. Oriskany.
Leptocælia flabellites ...	*Lepto. flabellites*, Conr. Orisk. and Cornit.
Vitulina pustulosa	*Vit. pustulosa*, Hall. Ham.
Anabocælia umbonata ...	*Anab. umbonata*, Conr. Marc. Chemung.
? *Tropidoleptus carinatus* ...	*Trop. carinatus*, Conr. Marc. and Ham.
Cryptonella Bainii	*Crypt. planirostra*, Hall. Marc. and Ham.
Cryptonella? sp.	*Oriskania pavicella*, Hall & Clarke. Oriskany.
Spirifer antarcticus + *Orbignyi*	*Sp. arrectus*, Hall. Oriskany.
Sp. cf. *pedroanus*	*Sp. undosonatus*, Conr. Marc., Ham., and Chem.
Spirifer Ceres	*Sp. varicosta*, Conr. Up. Held. *Sp. duodenarius*, Hall. Up. Held.
Sp. sp. α. Reed	*Sp. medialis*, Hall. Marc. and Ham. *Sp. undosonatus*, Conr. Marc., Ham., and Chem.

The ranges of the American forms are taken from Schuchert's list (18).

The foregoing list shows the strong and close affinities of the Bokkeveld brachiopods to those of the Devonian of North America, and it is remarkable that, according to Katzer (17, p. 139), in the case of the Brazilian members of the same group from the Maecuru Sandstone, there is a mixture of upper Lower Devonian and Middle Devonian forms, the Lower Devonian predominating; but in South Africa the facies is more that of the Middle.

Haug (11) has recorded several brachiopods from the Devonian beds of Tassili in the Sahara which suggest the presence of the Bokkeveld fauna, or at any rate of elements of it. The occurrence of *Spirifer* cf. *Rousseaui* has been mentioned above. The form called by Haug *Strophcodonta oriskania*, Clarke, and compared with Sharpe's *Chonetes*? sp. (14, p. 209, pl. xvi, fig. 14) from South Africa appears to me to resemble more closely my *Stroph.* cf. *concinna* Morr. & Sh. The specimen figured as *Chonetes* sp. by Haug may be compared with my *Ch.* aff. *setiger*. The important species *Leptocælia flabellites* is definitely identified by Haug from Tassili. Schwarz (2) doubts the accuracy of Haug's determinations, but apparently has only the figures by which to judge.

(c) *Mollusca.*

The list of Mollusca (22) (2) (23) from the Bokkeveld Beds is as follows:—

Orthoceras gaukaensis, Reed.	*Diaphorostoma*? sp.
O. bokkeveldensis, Reed.	*Tentaculites ecalcaratus*, Sharpe.
O. rex, Schwarz.	*T. bainii*, Reed.
Pleurotomaria aff. *Kayseri*, Ulr.	*Hyolithes subæqualis* (Salter).
Bellerophon quadrilobatus, Salter.	*Coniularia africana*, Sharpe.
B. (*Bucaniella*) aff. *trilobatus*, Sow.	*C. quichua*, Stein. Dod.
B. (*Bucaniella*) cf. *Reussi*, Clarke.	*C.* cf. *undulata*, Conr.
B. cf. *morganianus*, Hartt & Rath.	*C.* cf. *acuta*, Roem.
B. (*Plectonotus*) aff. *Salteri*, Clarke.	*Naculites abbreviatus* (Sharpe).
Loxonema sp.	*N. africanus* (Salter).
Holopea Bainii, Sharpe.	*N. Brauneri*, Clarke.

Nuculites capicensis, Reed.
N. columeus, Reed.
N. lunulata, Schwarz.
N. martialis, Reed.
N.? ovatus (Sharpe).
N. cf. *Smithi*, Clarke.
Palaeoneilo antiqua (Sharpe).
P.? arcuata, Schwarz.
P. Bowei, Schwarz.
P. radis (Sharpe).
P. subantiqua, Reed.
P. aff. *constricta* (Conr.).
P. cf. *ferunda*, Hall.
P. sp. ind., Reed.
Nuculana (= *Leda*) *inornata* (Sharpe).
Buchiola subpalmata, Reed.
B. sp. ind., Reed.
Cardiomorpha campestris, Reed.
Pterinea? sp., Reed.
? Cypricardella Pahli, Clarke.
Anodontopsis? radis (Sharpe).
Orthonota aff. *undulata* (Conr.).
Grammysia torrugata (Sharpe).
Gr. sp.
Sanguinolites niger, Reed.
S.? acris, Reed.
Glossites aff. *depressus*, Hall.
Nyassa arguta, Hall.
Modiomorpha Baini (Sharpe).
M. cf. *pinnulana*, Hartt & Rath.
M. aff. *Selloni*, Clarke.
Bassoplitria? sp.
Actinopteria aff. *Boydi*, Conr.
Act. sp. ind., Reed.

The relations of these species to those from the Devonian of South America are shown below:—

South Africa.	South America.
Orthoceras gaudacensis	*Orthoceras* sp. *a*. Ulr. B.
Pleurotomaria aff. *Kayseri* ...	*Pl. Kayseri*, Ulr. B.
Bellerophon cf. *morgianiadis* ...	*B. morgianianus*, Clarke. Br.
B. quadrilobatus	*B. Derbyi*, Cl. Br. *B.* sp. *a*. Ulr. B.
B. cf. *Reissi*	*B. Reissi*, Cl. Br. *B. cantabrina*, Cl. Br.
B. aff. *Salteri*	*B. Salteri*, Cl. Br.
Tentaculites cratalinus	*T. cratalinus*, Salt. A. *T.* sp. A. *T. bellulus*, Hall. B., Br.
T. Baini	*T. eldredgianus*, Hartt & Rath. Br.
Hyolithes subaequalis	*H. Schencki*, Ulr. B.
Conularia africana	*C. africana*, Sh. B.
C. quichua	*C. quichua*, Stein. Dod. B., A.
C. cf. *undulata*	*C. undulata*, Conr. B.
C. cf. *acuta*	*C.* cf. *acuta*, Roem. B.
Nuculites africanus	*N. Beneckei*, Ulr. B.
N. cf. *Smithi*	*N. Smithi*, Cl. Br.
N. Brauneri	*N. Brauneri*, Cl. Br.
Palaeoneilo radis	*P. Orbignyi*, Cl. Br.
P. antiqua	*P. Portlocki*. B.
Nuculana (= *Leda*) *inornata* ...	*L. diversa*, Hall. Br. *L.* sp. *a*. Ulr. B.
? Cypricardella Pahli	*C. Pahli*, Cl. Br.
Modiomorpha cf. *pinnulana* ...	*M. pinnulana*, Hartt & Rath. Br.
M. aff. *Selloni*	*M. Selloni*, Cl. Br.
Grammysia torrugata	*G. Derbyi*, Cl. Br.
Gr. sp.	*G. Gortanii*, Cl. Br.
Actinopteria aff. *Boydi*	*A.* cf. *Boydi*, Conr. B. *A. Eschwegei*, Cl. Br.

It is obvious from the above list that there is an unusually large number of closely allied or representative species amongst the mollusca. But we may note the absence from South Africa (so far as our present knowledge extends) of the genus *Platyceras*, which is represented in South America by ten or more species, and is very common in the Devonian of the Amazon. There are likewise some lamellibranch genera present (*Buchiola*, *Glossites*, *Cardiomorpha*, etc.) which appear

not to be present in South America, while the latter region possesses others (*Tachomya*, *Splenotus*, *Cimitaria*, etc.) which have not so far been definitely recognised in South Africa. But negative evidence of this kind under the circumstances is of little import.

Of Bokkeveld species of mollusca allied to or identical with North American Devonian forms, the following list may be given:—

South Africa.	North America.
Orthoceras bokkeveldensis ...	*O. typum*, Roem.
Pleurotomaria aff. *Kayseri* ...	*Pl. lucina*, Hall. Up. Held. and Ham. *Pl. Hebe*, Hall. Up. Held.
Loxonema sp.	*L. delphinida*, Hall. Ham.
Tentaculites crotalinus	*T. bellulus*, Hall. Ham.
Hyolithes subaequalis	*H. ligea*, Hall. Schoharie.
Conularia africana	*C. elegantula*, Meek. Up. Held.
C. cf. *undulata*	*C. undulata*, Hall. Ham.
Nuculites capensis	*N. oblongatus*, Conr. Ham.
N. martialis	*N. triquetra*, Hall. Ham.
N. cf. *Smithi*	*N. oblongatus*, Conr. Ham.
Palaeoneilo Bogeri *P.* cf. *fecunda*	*P. fecunda*, Hall. Ham.
P. aff. *constricta*	*P. constricta*, Conr. Ham.
Nuculana (*Leda*) *inornata* ...	*L. diversa*, Hall. Ham.
Buchiola subpalmata ...	*B. speciosa*, Hall. Genn.
Orthonota aff. *undulata* ...	*O. undulata*, Conr. Ham.
Grammysia sp.	*G. alveata*, Conr. Ham. *G. lirata*, Hall. Up. Held. and Ham.
Nyassa arguta	*N. arguta*, Hall. Ham.
Glossites aff. *depressus*	*G. depressus*, Hall. Chem. *G. lingualis*, Hall. Chem.
Modiomorpha Baini	*M. alta*, Conr. Ham.
Actinopteria aff. *Boydi*	*A. Boydi*, Conr. Ham.

There is a plain Hamiltonian (Middle Devonian) facies in the mollusca of the Bokkeveld Beds which is brought out by the above list. The same feature is noticeable to a certain extent in the Devonian of South America, especially in Brazil, according to Katzer (17, p. 199).

Haug (19) has recently recorded *Conularia africana* and *Actinopteria* aff. *Boydi* from the Devonian of the Central Sahara in addition to the brachiopods and trilobites above mentioned, and the evidence for the occurrence of the Bokkeveld fauna in Northern Africa is thus gaining strength.

(*d*) *Miscellaneous.*

The remaining few fossils from the Bokkeveld Beds belong to various groups, and comprise the following:—

Serpulites rica, Salter. — Ophiuroids (undescribed).
Ophioccinus Stangeri, Salter. — *Zaphrentis zebra*, Schwarz.

General Characters of the Fauna.

Reviewing the fauna as a whole, we note the abundance of species of brachiopods, lamellibranchs, and trilobites, and this abundance is also expressed in individuals. These groups compose the bulk of the whole fauna. Cephalopods are very rare, and corals are practically absent. Certain genera predominate in the three main groups:

amongst the trilobites *Homalonotus* and two special subgenera of *Phacops*; amongst the brachiopods *Spirifer*, and members of the genera variously termed *Rhynchospira*, *Retzia*, *Rensselaria*, and *Trigeria*, while *Lepto. flabellites* is the most abundant form of all. *Chonetes* is also represented by several distinct species, and is not an uncommon form. The most prominent Mollusca are *Bellerophon* (*Bucaniella*), *Conularia*, *Palaoneilo*, and *Nucalites*, the two latter containing at least 16 species. All other groups are very poorly represented.

Further research may somewhat alter the proportions of the various groups and reveal new species and genera, but is scarcely likely to lead to a complete re-casting of our conclusions.

Relations to Devonian Faunas of other Regions.

(*a*) *South America.*

The close relations of the Bokkeveld fauna to that of the Devonian beds of South America have been brought out in comparing the trilobites, brachiopods, and mollusca separately, and they have been remarked by all workers on the fossils. Katzer (15, p. 28) has especially compared the Amazonian fauna with it, and concludes that they are of the same age. The intimate nature of the relations between the several Devonian faunas of South America itself has been emphasised by the same author as well as by Clarke (8*a*, pp. 80–90) and Thomas (10).

(*b*) *North America.*

The same authors lay stress on the resemblance of these various Devonian faunas of South America to that of the Hamilton Beds of North America. Kayser (20, p. 317) had previously insisted on this point, and we have seen the strength of the same resemblance in the case of the South African fauna. Moreover, the same peculiar admixture of Lower Devonian forms with those of Middle Devonian age is likewise noticeable in South Africa, but the latter predominate and give the principal features to the fauna of the Bokkeveld Beds.

In South Africa there are species allied to or identical with those of the Upper Helderberg Group (including the Oriskany Sandstone), of the Hamilton Group, and of the Chemung Group; and Katzer (15, pp. 20–22) has recognised the same in the Amazonian faunas. The conclusion to which Thomas (10) is led with regard to the age of all the South American Devonian beds is that it is close upon the borders of the Lower and Middle Devonian. But Katzer is of the opinion that the Devonian fauna of the Amazon, and especially the Maecurú fauna, is more closely connected with the Middle than with the Lower Devonian of North America; and it is to this conclusion I am brought by the foregoing study of the affinities of the Bokkeveld fauna. The evidence of each zoological group, so far as it is known, points in this direction, and I believe it is largely the lithological resemblance of the beds to the well-known Spirifer Sandstone of the Rhenish Lower Devonian which at first inclines one to put the South African beds on the lower stratigraphical horizon. But to this feature reference is again made below.

(c) *Europe*.

If we compare the fauna of the Bokkeveld Beds with that of Southern and Western Europe, as Katzer (15, pp. 36–40) has done for the South American Devonian, we may together with him first notice that it is on the banks of the Bosphorus (24) that we seem to get a peculiar resemblance, as the Lower ? Devonian fossils described by De Verneuil (24) show. In connection with the Bolivian fauna Ulrich (9) has similarly drawn attention to this fact, and points to the presence of ribbed Centronellids, of members of the group *Bellerophon trilobatus*, of two species of *Homalonotus* allied to *H. acanthurus*, of a *Cryphæus* recalling *C. paitúna*, and of *Tropidoleptus carinatus* (usually described in Europe as *Strophomena laticosta*, D'Orb.). Clarke has referred to this resemblance in the case of the trilobites of the Maecurú (8, pp. 43, 46). Further investigation of these Bosphorus Beds might yield interesting and important results in this connection. But at present the evidence is scanty and insufficient.

In Western Europe it is in the fauna of the Coblenz Beds (upper Lower Devonian) that one finds the strongest and most numerous points of resemblance. As above mentioned, the similarity in the lithological characters of the rock and mode of preservation of the fossils are additionally suggestive and lend a certain assistance in any comparison. But when we come to compare the species separately and minutely we do not find such a close agreement or so much affinity as might be expected. Amongst the trilobites it is chiefly in the species of *Homalonotus* that we find degrees of relationship, and these may not be so close as has been urged (2). According to Lake *H. Herscheli* has its nearest ally in *H. armatus*, Burm, from the Lower Coblenz Beds; and *H. quernus* in *H. subarmatus*, Koch, from the Upper Coblenz Beds. The Phacopidæ belong to quite distinct types, though the Bokkeveld *Dalmanites* may belong (like *D. maecurua*, Clarke, from the Amazon) to the widespread *Hausmanni* group. Amongst the brachiopods we have the group of *Sp. antarcticus* closely related to *Sp. primævus* and its allies; *Ch. falklandicus* is allied to *Ch. sarcinulata*; *Retzia Adrieni*, De Vern., occurs typically in the Lower Devonian of Europe, and so does *Trigeria Gaudryi*; and *Ambocœlia umbonata* has been recorded from Western France; *Orthothetes Sulivani* has certain affinities with the well-known *O. umbraculum* from the Middle Devonian of Europe. *Rhynchospira ? Silveti* is probably allied to *Centronella Bergeroni*, Oehl., and perhaps to *C. Guerangeri* (De Vern.), both of the Lower Devonian, and *Ptychospira variegata* finds its nearest ally in the Middle Devonian form *Pt. ferita*, Von Buch, and the genus is not known from South America. *Rensselæria confluentina* is a Rhenish Lower Devonian species. If *Tropidoleptus carinatus* occurs in the Bokkeveld Beds it is represented in Europe by the identical *Strophomena laticosta*.

The Mollusca which show affinities to European forms are the following:—

Bellerophon aff. *trilobatus*	...	*B. trilobatus*, var. *tumidus*, Sandberger. Lr. Dev.
Conularia cf. *acuta*		*C. subparallela*, Sandb. Lr. Dev. *C. acuta*, Roem. Lr. Dev.
Grammysia sp.		*G. ovata*, Sandb. Lr. Dev.

Nuculites Brauneri)			
N. calonicus)	...	...	*Cucullella elliptica*, Maur. Lr. Dev.
N. capensis	...	...	*N. salvaides* (Giddf.). Lr. Dev.
Buchiola subpalmata	...	...	*B. palmata* (Giddf.). Mid. Dev.
Sanguinolites niger	...	...	*S. Marsi*, Ochl. Lr. Dev.
Actinopteria aff. *Boydi*	...	...	*Act. Trigeri*, Ochl. Lr. Dev.

We have therefore to acknowledge a certain degree of affinity to the fauna of the Coblenzian Beds, but it is of much less strength than that shown to the North American beds.

The problem, however, now confronts us of the alliance of the Bokkeveld fauna being closer with the *Middle* Devonian of North America than with the Lower, while in Europe it is with the undoubted *Lower* Devonian fauna that we find most points of resemblance. The same difficulty has to be faced with regard to the South American fauna, and Katzer (15) inclines to the explanation that the European Lower Devonian forms migrated to America, appearing and living on later there so as to form an element in the Middle Devonian of that area. Probably the physical conditions which they found, especially in South America, and we may add South Africa, were conducive to their persistence, as these resembled the Coblenzian of Western Europe. By this attitude Katzer is in favour of the non-contemporaneous appearance of the same or closely allied forms in Europe and America; and he suggests that the whole movement and dispersion of the faunas was connected with that widespread transgression of the Middle Devonian seas of which fresh evidence is constantly being found (25). It was, however, the typical West European Middle Devonian fauna which spread over the widest area, but its extension is found to the east of its well-known habitat in Western Europe, and not to the south or west. It has been discovered throughout Central Asia northwards to Shantung and southwards to Burma, and as far as Australia, a growing admixture of American forms being generally noticeable as we proceed eastwards. The characteristic calcareous development of this type is in marked contrast to the arenaceous or argillaceous nature of the South African and South American beds, and the physical conditions must naturally have largely influenced the composition of the faunas.

The whole question of the migration of faunas, particularly in connection with the Devonian beds of North America, has been recently discussed in much detail by H. S. Williams (31), and he has shown by a wide collection of facts and statistics that there was frequent lateral shifting, emigration, recurrence, and overlapping of faunas living in the same general marine province, with occasional invasions of strange faunas from neighbouring or distant areas. Migrations have been usually attended by modifications of some of the species, or of their proportionate abundance; other forms which were unable to shift or adapt themselves to new conditions with sufficient rapidity become extinct, while others are stimulated to mutation (in De Vries' sense) and new types are produced. An incorporation of elements previously existing in the invaded area may also be occasionally noticed. In this way the survival of an older fauna in its integrity, or at any rate of a considerable remnant, may take place owing to lateral shifting, and the lifetime (biochron) of any fauna does not necessarily, or even generally, coincide with the

limits of the formation in which it is typically developed, nor does faunal equivalency necessarily imply contemporaneity of formation.

If we look upon the Bokkeveld fauna in this light we may regard the European Coblenzian elements as the late survivals of a migratory movement from the north, while the general facies is that of the American Middle Devonian modified by and incorporated with the special fauna of the Southern Ocean and with the local types of the South African region of the period.

Distribution.

In the construction of Katzer's sketch-map (15, pp. 40–50) showing the general distribution of sea and land at the beginning of Middle Devonian times the distinctive characters of the faunas and of the rocks in which they occur have been utilised, and with the exception of Haug's important discoveries in the Sahara there has been no new evidence to disturb the general outlines there shown for the southern hemisphere. In the case of the northern hemisphere Schuchert's (27) work on the North American Devonian palæogeography and Lebedew's (28) researches on the distribution of Devonian corals in Asiatic Russia and Europe may necessitate some modifications into which one need not here enter. In his map Katzer shows a great continental mass of land which he terms the 'Atlantic-Ethiopian continent,' extending all over the North and Central Atlantic, covering a great part of North America and the whole of Africa, except the northern portion and the Cape. A great 'Southern Ocean' washes the southern shores of this continent, and on its eastern side this ocean is connected with the main European marine areas by an 'Indian Connecting Sea,' or rather broad straits, reaching up from the present Indian Ocean across Arabia and Asia Minor, and thus linking up the Bosphorus fauna with that of the Cape. On the west side of the 'Atlantic-Ethiopian Continent' a tract of water termed the 'Brazilian Connecting Sea' stretches across South America to the 'Great Pacific Ocean,' and this has a shallow bay invading Brazil, and a deeper bay cutting into the centre of the United States and forming the so-called 'Appalachian Bay.' It was in the 'Brazilian Sea' that the South American Devonian beds accumulated. A great 'Southern Continent' bounded this sea on the west, and extended across the South Pacific to New Zealand and north of it. Such is Katzer's schematic restoration of land and sea areas in the southern hemisphere in connection with his study and comparison of the South American Devonian. In so far as it applies to the Bokkeveld fauna all the evidence available goes to support its main outlines. Haug's discoveries in the Sahara may require a more direct connection of the Cape area with North Africa, and Central Africa is almost unknown geologically. The route by which the Coblenzian types of Western Europe found their way to the south and west is not so clear, as the 'Atlantic-Ethiopian Continent' would offer an insuperable barrier to a direct migration. Haug (32, p. 694) attacked the problems of palæogeography from the consideration of the position of the geosynclinals, and was led likewise to place a great land barrier (the 'Africano-Brazilian Continent') to the north of the sea in which the Devonian of South Africa and South America were deposited. But these views

were published prior to the Saharan discoveries. Schwarz (33) has called Katzer's 'Atlantic-Ethiopian Continent' by the simpler name of 'Flabellite Land,' after the characteristic fossil *Leptocælia flabellites*.

Frech (26, p. 239) has proceeded on the view that the Bokkeveld beds are of Lower Devonian age, and his restoration of the ancient geography differs somewhat from Katzer's. By the insertion of a narrow strait cutting across Katzer's 'Atlantic-Ethiopian Continent' and separating his own 'Indo-African Continent' from his 'North Atlantic Peninsula' (which corresponds more or less with the northern half of Katzer's aforesaid continent) he brings into connection the West European and South African faunas, which Katzer failed to do. The latter's 'Indian Connecting Sea' to the east of the present African continent finds no place in Frech's map, and we notice, too, the practical absence of the great 'Southern Continent' in the South Pacific, and the consequent merging of the 'Brazilian Connecting Sea' into the main Pacific Ocean. The 'Northern Helderberg Sea' of Frech's map corresponds somewhat to Katzer's 'Appalachian Bay' and passes southwards into the 'Southern Helderberg Sea,' which is represented as covering most of South America. A 'South Atlantic Island' more or less prevents a direct communication between the Cape and the Falkland Islands.

The restoration of past geographical conditions is not as a rule satisfactory, and such maps must be largely speculative, the real causes which determined the differentiation of the faunas being rarely ascertainable. The habit of imagining the existence of land barriers to account for differences in contemporaneous geological marine faunas may be carried too far, particularly in dealing with the distribution of molluscan faunas indicating water of moderate depths. The factors which are responsible are much more subtle and intangible. The present arrangement of marine zoological provinces round the coasts of the Atlantic affords a lesson and a warning. Apart from lithological characters of the beds and other geological considerations, the mere faunistic difference of contemporaneous beds is quite compatible with their deposition in the same ocean basin either along continuous coastlines or on opposite shores with open sea between them and without any land barriers to separate them. Differences of climate are frequently invoked to explain such difficulties, but we now know from marine biological research that climate is only one factor, and not by any means the most important one, in determining the characters and distribution of marine littoral faunas. Walther (30) has especially laid stress on the importance of bearing this in mind in dealing with the fossil contents of marine formations, and the modifications of Neumayr's Jurassic theories which recent work in South America, the Arctic regions, and elsewhere has necessitated, emphasise the wisdom of allowing for the action of other factors.

Conclusions.

Summing up the results of the foregoing survey we are led to the following conclusions:—

1. The Bokkeveld fauna is more closely allied to that of the Devonian of South America than to that of any other area.

2. This southern Devonian fauna is marked by the special development of certain peculiar subgenera (*Anchiopella* and *Metacryphæus*);

and by the predominance of other genera or groups (e.g. *Palæoneilo*, *Nuculites*, ribbed Centronellids, Bellerophontids of the *trilobatus* group), as well as by the absence or extreme rarity of many others and of certain groups, cephalopods, corals, bryozoans).

3. The affinities of this fauna are much closer to that of the Devonian of North America (eastern parts) than to the West European type.

4. The palæontological evidence tends to show that the Bokkeveld fauna is rather Middle Devonian than Lower Devonian when compared with North American faunas.

5. The European elements of the Bokkeveld fauna, on the other hand, have the facies of the Rhenish Lower Devonian (Coblenzian) rather than of the Middle Devonian of Western Europe.

6. These European elements, though generally recognisable in the southern fauna, are more strongly represented in South Africa than in South America.

7. The Bokkeveld fauna has a certain individuality of its own owing to the presence of certain peculiar genera (e.g. *Typhloniscus*) and species, in spite of its close relations to that of the South American Devonian.

8. The Bokkeveld fauna contains the following elements, in their order of relative importance and abundance: (1) species and groups identical with or allied to South American Devonian types; (2) species identical with or allied to Middle Devonian types of North America, including many in the first category; (3) species allied to Coblenzian species of Western Europe; (4) species or types peculiar to South Africa or with remote and obscure affinities.

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Corrigendum.—On p. 170 in the April number of this Magazine the species of *Phacops* mentioned as "a form compared with *Ph. rana*, Green . . . . . by Kayser," has been described by Mr. I. Thomas (10, p. 16) as a new species under the name of *Ph. argentinus*.

REVIEWS.

I.—New Memoir and Map of the Geological Survey of Ireland. The Geology of the Country around Limerick. By G. W. Lamplugh, F.R.S., S. B. Wilkinson, J. R. Kilroe, A. McHenry, M.R.I.A., H. J. Seymour, B.A., F.G.S., and W. B. Wright, B.A., F.G.S. 1907. 9½″ × 6″; pp. vi + 120, with 7 photographic process plates and 11 figures in text. Price 2*s*. [In explanation of map 1 inch to 1 mile ($\frac{1}{63360}$), Limerick District, Drift Series, parts of Sheets 143 and 144, colour-printed, published 1906, price 1*s*. 6*d*.]

THE area comprised in the map and described in the memoir amounts to 216 square miles, and includes Castleconnell, Caherconlish, Adare, and of course Limerick. The river Shannon enters the area on the north-east, bends westward, and flows for 20 miles generally westward.

The solid geology is described by Mr. J. R. Kilroe. The oldest rocks shown are Upper Silurian Llandovery beds, close to the northern margin of the map. They are calcareous shales, and grits and clay rocks, and have been intensely affected by pre-Carboniferous compression, which produced cleavage and here and there violent contortion along nearly east and west axes. The highly contorted and fractured Silurian beds were subjected to extensive denudation prior to the deposition of Upper Old Red strata, their upturned truncated edges forming the floor upon which the latter were laid down. The Upper Old Red Sandstone is usually a coarse yellow quartzose grit, sometimes conglomeratic and sometimes calcareous, and often having greenish sandy shale partings between the beds. It overlies the Silurian rocks near the north-west margin of the area, and forms the foothills of the Slievefelim range at the eastern margin. It conformably underlies the Lower Carboniferous series, but fossil evidence of its age is wanting.

The Carboniferous Lower Limestone Shale is about 50 feet thick, and forms a narrow band, 8 miles long and almost wholly concealed

by drifts, to the south of the Old Red Sandstone, near the northern margin and to the west of it in the Slievefelim district.

The overlying Lower Limestone consists in the lower portions of earthy limestone, in parts shaly, passing up into blue and grey limestone, much purer in quality than the lower strata, containing some chert, and being in certain places dolomitic.

It forms a strip ¾ to 1¼ mile wide (the northern limb of a syncline), overlying the Lower Limestone Shales in the north of the map area, forms an anticline over 2 miles broad in the south-eastern district, and occupies large areas on the east and west sides of the district.

The Middle and Upper Limestones are undistinguishable in this district. A band of cherty beds from 20 feet to 150 feet in thickness has been taken as characterising the incoming of the upper series, which includes the Middle and Upper Limestones. Large contemporaneous masses of igneous origin frequently come in just above the cherty beds. Over these cherty beds or, where present, over the igneous rocks are dark-blue, sometimes black, fetid, argillaceous limestones, that generally have thin shale partings between the beds; these are in some places succeeded, as we ascend, by another group of igneous rocks, and these again by blue compact limestone. The Upper and Middle Limestones, including the associated trappean rocks, are calculated to be about 2,000 feet thick. They occupy a great synclinal basin with minor anticlines in the centre of the area.

In the south-east corner of the area occur two series of beds, which were originally regarded as Coal-measures, but which correspond in stratigraphical position and approximately in age to the subdivisions that have been correlated elsewhere in Ireland with the English Yoredale Shale and Millstone Grit respectively and are now mapped as such.

Within the limits of the present sheet occur three large areas of igneous rocks, mainly of volcanic origin, and some seven smaller outlying areas. Viewed in association with similar rocks which appear throughout an area extending some twenty miles to the south-eastward, they render this region, in the words of Sir A. Geikie, "one of the most varied and complete of all the Carboniferous volcanic districts of Britain."

The igneous rocks described are Volcanic Tuff and Ash, Basalt and Dolerite and Trachytic Rocks (Orthophyre [Orthoclase porphyry] type). It has been generally held that the basaltic layers of Carrigagunnel and Boughilbreaga are contemporaneous and 'interbedded' with the tuffs of these localities. Mr. Kilroe cites evidence in favour of the view that they are intrusive. If, as is possible, the sills are of the period to which the great basic mass south of Ballybrood belongs, they would be more recent than the Millstone Grit, but how much more recent there is no evidence to show.

The Glacial Drifts. While most abundantly developed on the lower ground, the glacial deposits are found overlying the solid rocks in every part of the district.

Unstratified boulder-clay, the direct product of the ice-sheet, constitutes the most prevalent type of glacial drift, but there are extensive masses of stratified drift consisting of sand and gravel assorted and deposited by water. The two varieties of Boulder-clay

most prevalent in the present map are derived respectively from the Carboniferous Limestone and from the Old Red Sandstone.

Boulders of Carboniferous Limestone are more abundant than those of any other rock, and are so large and so numerous that it is sometimes difficult to decide from a small outcrop whether the limestone is in place or is part of a shifted block. Old Red Sandstone and the Carboniferous volcanic rocks likewise contributed their quota of boulders. Boulders of rocks entirely foreign to the district are of comparatively rare occurrence. The most notable are the blocks of granite recognizable as that which occurs in place on the north side of Galway Bay.

From the evidence afforded by the glacial scratchings on surfaces of rock and by the direction of transport of boulders, and other material incorporated in the drift, it is clear that the ice by which the country was overwhelmed had a general movement, from approximately north-west to south-east, though with many local deflections due to the irregularities of the ground. It is important to note that this direction is transverse to the Shannon, and is, moreover, not toward the western coast but trends somewhat inland. Post-Glacial deposits, consisting of Old River Gravels and Peat, complete the series of rocks of the district.

In the "Notes on the Soils and Subsoils," which are presumably intended for farmers, it seems to me unreasonable to give dimensions in millimetres and centimetres and weights in grams until the metric system is made compulsory in the British Isles.

At the foot of the map a longitudinal section from the Silurian hills on the north-west across the great syncline of Carboniferous rocks with a minor anticline in it south-east of Limerick, and then traversing between Cahernarry and Knockroe an anticline of Lower Limestone overlain on either side by thick beds of basalt and volcanic ash, extends to a point one mile west of Ballybrood House. The abrupt right angle drawn in the centre of the anticline and the sharp zigzags in the Silurian rocks look rather unnatural. B. Hobson.

II.—Ightham: the Story of a Kentish Village and its Surroundings. By F. J. Bennett; with contributions by W. J. Lewis Abbott, E. W. Filkins, Benjamin Harrison, J. Russell Larkby, J. Scott Temple, and H. J. Osborne White. Small 4to, cloth; pp. viii + 158, with 40 illustrations, maps, and plans. London: The Homeland Association, Ltd., 1907.

IGHTHAM and the surrounding districts are sufficiently rich in geological and archæological interest to deserve the distinction of a monograph. Such a work might have been expected long ago from Mr. Benjamin Harrison, with his unrivalled local knowledge. But Mr. Harrison, though unsparing of his pen in correspondence, exercises excessive self-restraint in committing manuscript to the printer; and it has therefore been left to others to take up the work. When Mr. Bennett, on retirement from the Geological Survey some years ago, settled at West Malling, he became an enthusiastic student of the neighbouring country; and feeling, after a while, that Ightham needed its historian, he determined personally to supply the want.

As the result of several years' work, aided by friends whose assistance is freely acknowledged, he has just contributed to "The Homeland Library" an interesting volume, which will be welcomed by the student of geology and archæology as a convenient guide to a locality of exceptional attraction.

In Mr. Bennett's close study of the district he found it desirable to undertake a re-survey of the Drift on the 6-inch map. This detailed work led him to recognize a special type of deposit, which he distinguishes as 'scarp drift.' Occurring as terraces at the foot of the Chalk escarpment and running up the coombes, it is composed largely of pellets of chalk, passing into a loam, and is regarded by the author as the relics of the great denudation of the Chalk scarp. The classical problem of the denudation of the Weald naturally claims discussion at some length. Not satisfied, like many others, with the adequacy of Ramsay's views, the author invokes with Prestwich the aid of glacial action; but, after all, considers that the problem remains unsolved, since none of the theories put forward completely meet the case. "In our opinion," says Mr. Bennett, "the various causes of the denudation of the Weald are still to be sought for, and the question may still be considered to be an open one."

To explain the formation of the deep gorge of the Shode, the author supposes that subaerial denudation was assisted by subterranean erosion. He holds that the underground flow of water in the Hythe Beds, pent up between the Atherfield Clay below and the clayey Sandgate Beds above, would effect much erosion; and that when the stream, in working downwards, cut any water-bearing joints the released water might rush up by hydrostatic pressure, as in an artesian well, thus materially assisting the denudation, whilst subsidence would be a contributory factor in the formation of the valley.

The Eolithic question, which has done so much to make Ightham famous, is fully dealt with; but it is doubtful whether many anthropologists will care to follow the author in his recognition of a yet earlier 'Lithic period.' Mr. Larkby contributes a chapter on the development of flint implements, whilst Mr. Bennett describes the palæolithic rock-shelters at Oldbury and the megalithic remains in neighbouring districts. Mr. Scott Temple writes on many of the historical monuments, and Mr. Filkins describes the famous Mote House, whilst the rather curious subject of gravestones is dealt with by Mr. Bennett.

One of the most interesting sections of the work is Mr. Lewis Abbott's description of the bone-bearing fissures in the limestone of the valley of the Shode, in which he summarizes his remarkable researches, so well known to geologists. Incidentally he remarks that he still has probably 20,000 relics awaiting examination. Finally, Mr. Osborne White contributes an appendix on the Chalk of Ightham.

It remains to add that the work is well illustrated, mostly from photographs. A portrait of Mr. Harrison appropriately forms the frontispiece, whilst several plates of stone implements represent specimens in the "Harrison Collection," now in the County Room of the Maidstone Museum, where they have been photographed by Mr. Elgar, the sub-curator.

III.—Volcanoes.

Les Volcans de la Terre. Par Élisée Reclus. Premier Fascicule. 1906. Société belge d'Astronomie, de Météorologie, et de Physique du Globe, Brussels.

THE work of which the title of the first part is given above is the outcome of a proposal made by the late M. E. Reclus to publish a work descriptive of the volcanoes of the world. The complete work is to comprise 1,500 pages and to be illustrated by maps and figures. The subscription price is 25 francs for an ordinary copy, and 50 or 100 francs for éditions de luxe on superior paper.

The first part consists of 168 pages ($10 \times 6\frac{1}{4}$″), and is devoted to "Asie Antérieure." The first chapter (pp. 11 to 30) deals with Persia. After a short sketch of the physical features of the country, the chief volcanoes, such as Demavend (of which a map and geological section, after Stahl, are given), etc., are described, and the chapter concludes with a bibliography of books, papers, and maps.

The method followed in succeeding chapters is similar. The second chapter (pp. 31 to 75) treats of Armenia, and in this chapter Ararat is described under the unfamiliar Armenian name of Masis, and a map of Ararat and Ala-Göz is given. Dr. Felix Oswald's work on the geology of Armenia appeared too recently to be included in the bibliography.

Chapter iii (pp. 75–98) deals with Syria, Chapter iv (pp. 99–130) with Asia Minor, Chapter v (pp. 131–163) with the Caucasus.

The comment one feels disposed to make is that the descriptions are rather those of the traveller than of the geologist. That of Elbruz (Caucasus) is rather meagre. The name of the rock of which its lavas consist is not mentioned. All that is said of them is, "Ses coulées sont formées d'une roche à pâte noire semi-vitreuse contenant de gros grains de quartz et des cristaux d'oligoclase et de pyroxène; un peu de biotite [misprinted biolite] et de magnétite s'y mêle." This is a mangled quotation from the Guide des Excursions of the International Geological Congress of 1897 (St. Petersburg). There is no excuse for so vague and unsatisfactory a description of the lavas of Elbruz, since Dr. A. Dannenberg published in Tschermak's Mineralogische und Petrographische Mittheilungen, vol. xix (1900), pp. 218–242, his "Beiträge zur Petrographie der Kaukasusländer," in which a full account of the hypersthene amphibole dacite lava of Elbruz is given. In the second part of Dr. Dannenberg's paper in vol. xxiii (1904) of the same periodical a pyroxene andesite from Ala-göz in Armenia is described, though in Reclus' description only obsidian, scoria, basalt and pumice, and artificial tombs of trachyte are mentioned. Interesting as this great work on volcanoes is, more attention must be paid to geological structure and composition of volcanic products if the work is to have scientific value. The names of collaborators are not given. A competent geologist and petrographer should be among them to check the loose petrographical names often given by travellers. It is as important that species should be correctly named in the case of rocks as in that of fossils.

B. Hobson.

REPORTS AND PROCEEDINGS.

Geological Society of London.

March 27th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "On the Southern Origin attributed to the Northern Zone in the Savoy and Swiss Alps." By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.G.S.

Professor Lugeon, with some other eminent Continental geologists, explains certain peculiar flat folds, the higher of which sometimes project considerably beyond the lower, in the more northern sedimentary zone of the Swiss and Savoy Alps, by supposing that to no small extent the strata have been thrust forward from an original position south of the watershed of the Pennine-Lepontine Alps; overriding, as they advanced, their crest and that of the Oberland (neither having then attained its present altitude). This pressure was produced by the greater thickness of deposits of Mid-Tertiary age, speaking in general terms. Professor Sollas, in concluding a very interesting and suggestive paper on some experiments with cobbler's wax, published in the last volume of the Quarterly Journal of the Society, p. 716, suggests that the results are favourable to the views of the Lausanne professor.

The author takes exception to some of the cases, especially two to the east of the Simplon Pass, which are adduced by Professor Lugeon in support of his hypothesis, pointing out that he has confused an ordinary with a crystalline limestone, and merely schistose slates with true crystalline schists. But, without going into the details of sections, he shows from general reasoning that both the kind and the amount of transport, postulated by Professor Lugeon, introduce serious mechanical difficulties. Sediments are assumed to have been transported from (say) near Ivrea to the northern margin of the Alps on either side of the Rhone valley below Martigny; that is, to have travelled something like 75 miles. As the average thickness of the Secondary and older Tertiary strata in this part of the Alps can hardly exceed 2·5 miles, we can form a general idea of the problem by drawing an oblong 30 times as long as high. Then, material at one end (southern) has to be squeezed across obstacles to near the other, by piling a wedge-like mass of sediment on a southern prolongation of the oblong, the thin end of which mass may perhaps trespass a little on the northward side of the original southern boundary.

After discussing the problem in some detail, the author shows that in Professor Sollas's experiments there was, at the beginning of loading, a wedge instead of an oblong; the distance to be traversed was six times the maximum thickness of the (supposed) sedimentaries, instead of about 30 times; and the slope of the added mass was about double that which, in the Alpine case, is supposed to be the sole

cause of the movement. Lastly, in the case which presents by far the greater difficulties, the material is limestone and shale instead of cobbler's wax. The author maintains that Professor Lugeon's hypothesis receives no real support from Professor Sollas's experiments, and involves mechanical difficulties which are practically insuperable.

2. "The Coral Rocks of Barbados." By Professor John Burchmore Harrison, C.M.G., M.A., F.I.C., F.G.S.

The results of the author's extended, and in many places detailed, re-examination of the coral rocks in the southern half of Barbados, give no support to Dr. J. W. Spencer's theory of the existence of strata of the "Antigua Formation" in that island. It is now shown that a certain knoll, whence Dr. Spencer collected corals which in his estimation proved that it and other parts of the coral rocks were of Oligocene age, is in part made up of corals which, as stated by Professor J. W. Gregory, "certainly show no evidence of any age greater than the Pleistocene." The author has failed to find any signs of the widespread formation, described in Dr. Spencer's paper as extending from Mount Misery to near Ragged Point, a distance of about 11 miles, and dipping south-eastward at from 12° to 20°. Such a formation would be about 15,000 feet thick; while the facts that nowhere in the island does the combined thickness of the limestone and of its basal or Bissex Beds exceed 280 feet, and that the limestone is not traversed by faults, are fairly conclusive evidence of the non-existence of such a formation. This dip is referred to the action of landslips in some cases, and in others to current-bedding. The author's recent investigations have confirmed the statements made and the views expressed by Mr. Jukes-Browne and himself in the notes published in the Geological Magazine for December, 1902, p. 550.

CORRESPONDENCE.

SANDSTONE PIPES IN CARBONIFEROUS LIMESTONE, ANGLESEY.

Sir,—In the Geological Magazine for January, 1900 (p. 20), was published a paper (read and discussed at the Dover Meeting of the British Association in 1899) on Sandstone Pipes in the Carboniferous Limestone of Anglesey, in which I showed that they formed a part of the Carboniferous Series, and were evidently due to some unusual kind of contemporaneous erosion.

In November last Professor W. H. Hobbs, Secretary of the American Seismological Committee, wrote to me suggesting that these pipes might be the 'craterlets' of Carboniferous earthquakes, produced by disturbance of underground waters in the same way as those of the Calabria, Charleston, and other shocks of recent times. Some of those of Calabria are figured in Lyell's Principles. The Comte de Montessur de Ballore, to whom Professor Hobbs asked me to send photographs, has concurred, after some correspondence, in this explanation.

Both authors will discuss the phenomenon, together with certain kindred ones, in works now in the press, and as these will be published outside this country the object of this letter is to invite the attention of British geologists to this very curious and most original suggestion.

EDWARD GREENLY.

P.S.—Perhaps I might add that the pipes are very near to a zone of powerful faulting, which, though displacing the Carboniferous rocks more than 1,000 feet, was almost certainly a line of movement in much older times. Movement along it, therefore, was very likely going on at intervals during the Carboniferous period itself.

FOSSIL FOOTPRINTS IN THE SECONDARY ROCKS.

SIR,—I am returning to the study of the Triassic footmarks of the Connecticut, and would be glad to correspond with the Officers of Museums with reference to slabs of Ichnites found especially in Great Britain. My experience leads me to believe that the tracks of animals on stone are more abundant than is commonly supposed, and that there is much to be learned from their study. Although rather bulky, a place can be found for them in the Exhibition Rooms, and perhaps exchanges can be negotiated.

C. H. HITCHCOCK,

Curator of the Butterfield Museum, Dartmouth College, Hanover, New Hampshire, U.S.A.

March 7th, 1907.

CONODONTS IN COAL-MEASURE STRATA.

SIR,—Not long ago I sent you a notice of the occurrence of marine fossils in the Upper Coal-measures (Scotland). From the same bed I have now to record the finding of a few Conodonts, the determinable species being *Centrodus lineatus*, Pander, and *Polygnathus (Gnathodus) Mosquensis*, Pan. Both these forms were found by Pander, of Russia, in the Mountain Limestone of Moscow, and they occur in both the Upper and Lower Carboniferous Series of Scotland. *C. lineatus* has been got in the Devonian rocks of Canada and Carboniferous of Ohio. The list of fossils from this bed is as follows, all the forms being dwarfed except the Conodonts, which could not be made much smaller:—

Productus semireticulatus.
Chonetes Hardrensis.
C. Buchiana.
Athyris ambigua.
Discina nitida.
Lingula mytiloides.
Pecten, ribbed.
Posidoniella vetusta.
Murchisonia striatula.
Dentalium?
Nautilus?
Polyzoan, badly preserved.
Cladodus.
Coprolites and fish-remains.
Plants and vascular tissue.
Centrodus lineatus.
Polygnathus Mosquensis.

The position of this marine bed is pretty well up in the Coal-measure Series, probably a short distance above the Craigmark Ironstone, Craigmark Glen, Dalmellington.

J. SMITH.

DYKES, DALRY,
AYRSHIRE.

OBITUARY.

CARL LUDOLF GRIESBACH, C.I.E., F.G.S.

Born December 11, 1847. Died April 13, 1907.

It is with deep regret that we record the death of Mr. C. L. Griesbach, C.I.E., F.G.S., late Director of the Geological Survey of India, from July 17th, 1894, to February 24th, 1903.

Mr. C. L. Griesbach was born in Vienna on December 11th, 1847, and was the eldest son of Mr. George L. Griesbach, of Zobelsberg, a British subject. Carl was educated at the University of Vienna, and was for some time engaged upon the Geological Survey of Vienna, where he acquired his experience as a field geologist and palæontologist. He commanded a German scientific expedition to East Africa 1869–70, and on his return resided in London from 1871 to 1878, where he was engaged in scientific work; he was also a most accomplished artist. He communicated an important paper "On the Geology of Natal in South Africa" to the Geological Society (see Quart. Journ. Geol. Soc., vol. xxvii, 1871, pp. 53–71, with many illustrations prepared by himself). In 1878 he was appointed Assistant Superintendent to the Geological Survey of India, and joined in Calcutta the same year. He passed through various grades of promotion from 1880 to 1884. From 1884 to 1886 Mr. Griesbach was employed on the Afghan Boundary Commission, with the grade of Deputy Superintendent, and was raised to first grade Superintendent in November, 1886. He was created a Companion of the Indian Empire in February, 1887. From January, 1888, to July, 1889, his services were placed at the disposal of H.H. the Amir of Kabul, and he was made a Superintendent in 1889, and—on the retirement of Dr. William King, F.G.S.—Director of the Geological Survey in 1894.

When resident in London he served as an Officer in the Royal London Militia, now the 6th Battalion Royal Fusiliers, and has since been retired with the rank of Lieutenant-Colonel.

A list of twenty-six scientific papers by Mr. Griesbach will be found in the Geological Magazine for June, 1903, pp. 287–288; also of his special war services in India. Mr. Griesbach, in 1869, married Emma, daughter of the Rev. W. R. Griesbach, M.A., of Millington, Yorkshire, who died in 1892, leaving two children. He has lately resided in Graz, Austria, with his daughter. His only son, Walter, is at Revelstoke, E.C. For the last year Mr. Griesbach has been suffering from thrombosis, and although at times slightly better he succumbed to this malady on the 13th April, at the age of 60.

Mr. Griesbach served for twenty-five years on the Geological Survey of India. He was a Foreign Member of the k.k. Akademie der Wissenschaftlich Wien and numerous other learned societies. He was decorated for the Boundary Commission; received the Afghan medal and clasp, the Burma medal and clasp, the Nishaw-i-Hurmat (Afghan order); H.I.M. the Emperor of Austria-Hungary presented him with the Austrian gold medal in connection with the scientific expedition to the central regions of the Himalayas in 1892. He was elected a Fellow of the Geological Society of London in 1871.